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THE RELATION OF THE CERVICAL SYMPATHETIC TO THE EYE

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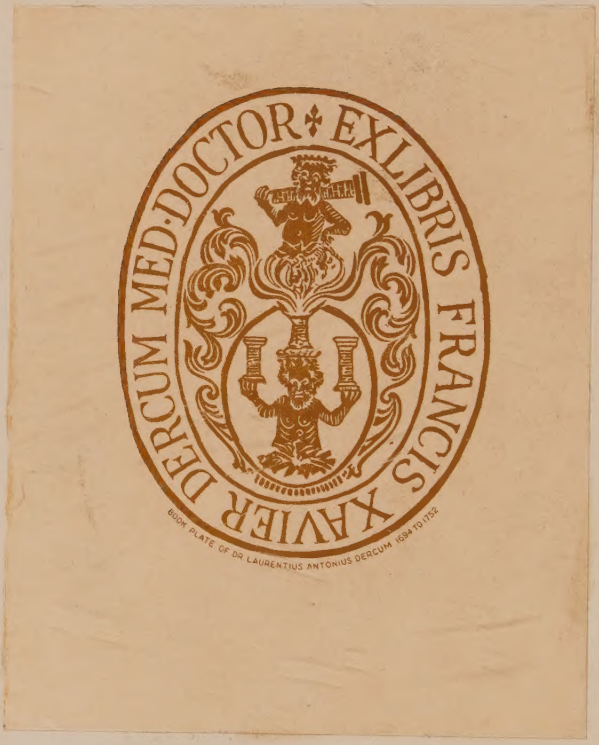

The Relation of the Cervical Sympathetic to the Eye

Papers read before the Section on Ophthalmology of the American Medical Association, at the Annual Session, New Orleans, May, 1903

"The Physiology of the Sympathetic in Relation to the Eye."

G. E. de Schweinitz, A.M., M.D., Philadelphia.

"The Influence of Resection of the Cervical Sympathetic Ganglia in Glaucoma."

William H. Wilder, M.D., Chicago.

"Influence of Resection of the Cervical Sympathetic in Optic-Nerve Atrophy, Hydrophthalmos and Exophthalmic Goiter."

James Moores Ball, M.D., St. Louis.

"Pathology of the Cervical Sympathetic."

John E. Weeks, M.D., New York.

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THE PHYSIOLOGY OF THE SYMPATHETIC IN RELATION TO THE EYE.

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The object of this paper is to present a résumé of our knowledge of the physiology of the sympathetic in so far as it relates to the eye, and is based on a study of the extant literature. This literature has assumed large proportions, and it must be evident that in the limited time at my disposal it would be impossible to review it elaborately. The endeavor, therefore, has been to bring into prominence such physiologic problems, and the subjects related to them, and to a minor degree some subjects suggested by them, which are of particular interest to us as ophthalmic surgeons.

I. INTRODUCTORY REMARKS ON THE ANATOMY AND PHYSIOLOGY OF THE SYMPATHETIC.

To introduce the subject it seems proper to say a word or two in regard to the general anatomy and physiology of the sympathetic. Following Professor Thane's classification,[1] which has also been adopted and elaborated by Onuf and Joseph Collins,[2] it may be said that the sympathetic nerve is composed of a collection of ganglia, cords and plexuses, or, more specifically, of two great gangliated cords, intermediate and peripheral plexuses and terminal ganglia. The great gangliated cords lie partly in front and partly on the side of the vertebral column, extending from the base of the skull to the coccyx. The number of ganglia in general terms corresponds to the vertebræ against which they are placed, except in the neck, where there are only three

1. Quain's Anatomy, vol. iii, part 2, 1895, p. 357.
2. Arch. of Neurol. and Psycho-Pathol., vol. iii, Nos. 1 and 2, 1900, p. 6.

ganglia. The connection between the gangliated cords and the cerebrospinal system is brought about by short filaments called communicating rami, which are of two kinds, one consisting chiefly of medullated fibers and the other of pale fibers. The medullated fibers of the white communicating rami proceed from both roots of the spinal nerves, but to a great extent from the anterior, and pass to the sympathetic cord. Not all of the spinal nerves, however, furnish these rami. In man it is believed that they exist from the first dorsal to the first or second lumbar nerves, and perhaps also to the third. The gray communicating rami pass between all of the spinal nerves and the sympathetic cord. The fibers arise in the nerve cells of the ganglia of the sympathetic cord, and enter the primary anterior division of a spinal nerve.

As not specially germane to the present topic, the interfunicular rami, the efferent rami, the great prevertebral plexuses, the peripheral plexuses, and finally, the monocellular ganglia, need not be discussed.

The general plan of arrangement of the sympathetic supplied to the head, quoting Langley,[3] is as follows:

> The upper part of the thoracic spinal cord sends out fibers by the anterior roots of the spinal nerves of this region. These fibers make no halt at the ganglia until they reach the superior cervical ganglion. This is a relay station for the sympathetic nerve supply for the whole of the head. In it all the nerve fibers form nerve endings, synapses, as they are called by Foster. Each nerve cell sends off a nerve fiber which runs to the periphery, where it branches and supplies a group of unstriped muscle or gland cells. On the course of a nerve impulse from the spinal cord to the periphery, there are, then, two nerve cells, one with cell body in the spinal cord, the other with cell body in the local sympathetic ganglion.

The centrifugal fiber of the first nerve cell is called by Langley the preganglionic fiber, by Kölliker the fiber of the first order; that of the second nerve cell the post-ganglionic fiber (Langley), or motor fiber of the second order (Kölliker). The majority of post-ganglionic fibers of the superior cervical ganglion pass to the fifth cranial nerve and are distributed with its sensory fibers; for example, the pupillodilator fibers and other fibers destined to the eye pass to the ophthalmic branch of the fifth and the long ciliary nerves.

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3. Text-Book of Physiology, edited by E. A. Schäfer, vol. ii, 1900.

Vasoconstrictor fibers to the iris run in the internal carotid plexus, and not, according to Francois-Franck, in the cervicogasserian strand. There are also post-ganglionic fibers for the superior cervical ganglion which proceed to the third and to the sixth cranial nerves, which might be supposed, as Langley suggests, to convey vasomotor fibers of the vessels of the ocular muscles, but thus far experiments have failed to prove that they have this function.[4] In other words, we come to study that part of a system of efferent ganglionated nerves which relates to the eye, a system, to quote from Gaskell, which is characterized by the fineness of its fibers, which are always medullated when they leave the central nervous system; by the presence on each of these fine, medullated fibers, in some part of its course, of a ganglion cell, from which fibers of the same physiologic character pass to the end-organ, and we remember in this study that this system includes not only the cells of the sympathetic, but also vagrant motor cells, such as are found in the course of the accessory vagus, in the ganglion trunci vagi, and in the course of the third nerve in the ciliary ganglion.

II. DISTRIBUTION OF THE SYMPATHETIC TO THE EYE.

The sets of sympathetic fibers which pass to the eye and its adnexa, following Thane's classification, may be described as follows:

1. *The Pupillodilator Fibers.*—These arise from the first, second and third dorsal nerves, which are connected with the superior cervical ganglion by means of slender cords which belong to the group of the gray communicating rami. They pass upward in the ascending or carotid branch of the first cervical ganglion and arrive at the plexus around the internal carotid artery and the gasserian ganglion. They reach the eyeball through the nasal branch of the ophthalmic nerve, or the first division of the fifth, by means of its long ciliary nerves, which perforate the sclerotic and are dis-

4. Jendrassik divides the sympathetic into two systems, namely, the spinal system and the vagus system. He describes a third connection between the central nervous system and the organs, which is called the dilator system. The duty of this system is to maintain a tonus acting antagonistically to the sympathetic system, that is, to Jendrassik's motor system. It contains the dilator fibers of the iris and of the blood vessels. For a résumé of Jendrassik's views, see Arch. of Neurol. and Psycho-Pathol., vol. iii, 1900, pp. 9-13.

tributed to the ciliary muscle, the iris and the cornea. It is believed by some observers that pupillodilator fibers are also contained in the seventh and eighth cervical nerves. A minute filament passes with the central artery of the retina into the eyeball.

2. *Motor Fibers to the Involuntary Muscles of the Orbit and Eyelids.*—These, according to Langley, proceed from the highest fourth or fifth dorsal nerves and their communicating rami. The involuntary muscle of the orbit which receives this sympathetic supply was originally described in 1858 by H. Müller. It is a rudimentary layer of unstriped muscle which bridges over the sphenomaxillary fissure and infraorbital groove, and corresponds to a more largely developed layer which is found in the extensive aponeurotic part of the orbital wall in various mammalia. This muscle, usually called Müller's orbital muscle, and sometimes the sphenomaxillary muscle, when it contracts, causes the globe of the eye to start forward, that is, to project more from the orbit.

The involuntary muscle of the eyelids consists of a layer of unstriped muscular tissue in each eyelid, which was also originally described by Müller. The layer of the upper eyelid arises from the under surface of the levator palpebræ, while that of the lower springs from the neighborhood of the inferior oblique muscle. Each of these layers is inserted near the attached margin of the tarsus. According to Henle, some of these fibers also have a transverse course. The collection of involuntary fibers in the lower lid is much less produced than that in the upper. According to Dwight, the function of Müller's muscle in the upper lid is to draw the skin to the fold above the tarsus when the lids are open.

3. *The Vasomotor Fibers.*—In so far as the head is concerned, according to Langley, these vasoconstrictor fibers are given off in the dog and cat chiefly by the second, third and fourth dorsal nerves. It is probable that vasodilator fibers also exist.[5]

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5. Onuf (see Note 2) has prepared a functional topography of the sympathetic nerves and their correlations in the cat, as established on the ground of physiologic experiment. As he himself points out, an important drawback to this topography is that it does not relate to man, but predominately to the cat. It may be interesting to quote from this the following: According to Budge, Salkowski and other observers, the pupil-dilating fibers of the cervical sympathetic are derived in part from the seventh and eighth cervical nerves through their communicating rami.

4. *Secretory Fibers.*—These are derived, in so far as the submaxillary gland is concerned, from the third, fourth and fifth dorsal, and are interesting to us because, according to Langley,[6] the results of physiologic investigations on the salivary glands may be applied with little change to the lachrymal glands, which in their histologic and physiologic characters resemble albuminous salivary glands. Their cranial secretory fibers come through the lachrymal branch of the fifth nerve. Their sympathetic fibers are derived from the cervical sympathetic and the blood vessels of the gland.

III. THE RELATION OF THE SYMPATHETIC TO THE LACHRYMAL SECRETION.

Reasoning from analogy, one would expect that stimulation of the cervical sympathetic, which causes secretion from the salivary glands, would also give rise to secretion from the lachrymal glands, and this, in fact, is usually stated to be one of its well-established effects. Authors, however, are not in accord on this point. Campos[7] thus reviews the contradictory evidence: Herzenstein, although he failed to obtain any result by section of the sympathetic cord below the superior cervical ganglion, or by excitation of its upper end, nevertheless believes that the sympathetic determines a secretion of tears different from that which is produced by the trigeminus. Wolferz and Demtschenko[8] have provoked lachrymal secretion by excitation of the sympathetic, while Reich observed a similar result in only a few cases. Arloing, experimenting on the bullock and goat, failed to obtain any result by exciting the upper end of the vagosympathetic cord, while its section was immediately followed by hypersecretion. Tepliachine, on the other hand, arrived at exactly opposite conclusions. Campos' own experiments have led him to believe that

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Langley, however, denies that any of the pupil-dilating fibers are derived from the cervical nerves. He also denies that the latter give origin to the vasoconstrictor and vasodilator fibers for the head. The chief nerve for dilatation of the pupil for the nictitating membrane and for Müller's muscle arises from the first dorsal. Dilator fibers for the pupil, motor fibers for the nictitating membrane and Müller's muscle are also derived from the second and third dorsal, and a few motor fibers for the nictitating membrane from the fourth dorsal, perhaps, also, from the fifth dorsal.

6. Text-Book of Physiology, edited by E. A. Schäfer, vol. i: The Salivary Glands, by J. N. Langley, p. 475.

7. Archiv d'Ophthalmologie, vol. xvii, p. 529.

8. Archiv f. Physiologie, Bd. vi, 1872, p. 191.

stimulation of the upper end of the cervical sympathetic does not cause lachrymal secretion, and that its section in man is without influence on the normal humidity of the eyes and on lachrymation. Levinsohn,[9] after section of the cervical sympathetic, or removal of the superior ganglion in monkeys, noted lachrymation on the operated side, which was most noticeable immediately after the operation, and had disappeared on the following day. This lachrymation, he concludes, is due to the vascular hyperemia which follows the section and therefore the sympathetic should not be considered the nerve of secretion for the lachrymal gland.[10]

IV. THE INFLUENCE OF THE SYMPATHETIC ON THE MOVEMENTS OF THE IRIS—THE CILIOSPINAL CENTER AND THE MYDRIATIC TRACT OF THE PUPIL.

The mechanism of the dilatation of the pupil, and whether the presence of a distinct muscular structure, to which the name dilatator pupillæ has been given, should be admitted, have occasioned much discussion.[11] Langley and Anderson[6] have summarized the matter as follows:

1. Dilatation of the pupil may be due to the action of the sympathetic vasoconstrictor fibers, stimulation of which causes either a decrease in the quantity of blood in the iris, so that it shrinks, or a longitudinal contraction of the radial arteries of the iris, which causes dragging of the sphincter outward.

2. Dilatation may be caused by contraction of ra-

9. Archiv f. Ophthalmologie, Bd. lv, 1902, p. 144.

10. In this connection it is interesting to note that section of the cervical sympathetic has no observable permanent effect on the salivary gland, and it causes no paralytic secretion; the primary dilatation of the blood vessels soon disappears. Excision of the superior cervical ganglion is not followed by any certain effect on the salivary gland (Langley).

11. This subject is too extensive to admit of much elaboration in the present paper. Those who are interested in the literature of the subject and in the controversies which have arisen concerning the presence or absence of a dilatator pupillæ may, with advantage, consult: Frank Baker, the Anatomy of the Eyeball, System of Diseases of the Eye, edited by Norris and Oliver, vol. i, p. 186; George A. Piersol, The Microscopical Examination of the Eyeball, Ibid., p. 279; Heese, Ueber den Einfluss des Sympatheticus auf das Auge, insbesondere auf die Irisbewegung, Archiv f. d. ges. Physiolog., Bd. lii, 1893; Gaskell, Innervation of the Sympathetic Nerves in Relation to the Dilator of the Eye; J. N. Langley and H. K. Anderson, The Mechanism of the Movements of the Iris, Journal of Physiology, vol. xiii, 1892.

dially arranged muscular fibers, a view maintained by Henle, Budge, Sappey, Kölliker, and many others.

3. The dilatation may be due to inhibition of the sphincter muscle, that is, as Grünhagen expressed it, the sympathetic may be regarded as an "erschlaffungs-nerv" of the sphincter, or, as Francois-Frank expressed it, the sympathetic dilator nerves of the iris may act in the same manner as the dilator nerves of the vessel, and suspend the activity of the constrictor nerves. Gaskell, referring to Grünhagen's contention that the radial fibers in the posterior limiting membrane of the iris are not true muscular fibers, agrees with him and does not see the necessity of assuming the presence of a dilator of the pupil, because one may assume that the nerves which dilate the pupil act on the sphincter muscle; in other words, that they are inhibitory nerves, or dilator nerves of that muscle. According to him, the sphincter muscle of the iris represents an example of a muscular structure which is supplied by two nerves of opposite character, one a motor and the other an inhibitory nerve.

4. Dilatation may be due to relaxation of the elasticity of part of the ciliary region and the anterior part of the choroid, which pulls backwards the iris.

5. Dilatation may be caused by the simultaneous action of more than one of the above-mentioned causes.

Both Frank Baker and George A. Piersol[11] think that the combined anatomic and physiologic evidence of the existence of a radially arranged dilator muscle is conclusive; while Jessop[12] maintains that he has never seen any fibers that could be compared in thickness with the sphincter of the pupil, or capable, physically, of overcoming the sphincter fibers and producing dilatation of the pupil. Whichever of these two, in some respects diametrically opposed views, is accepted, there is no question that the dilating impulse transmitted to the iris passes through the cervical sympathetic, and, in general terms, along what is called the mydriatic tract of the pupil, which may now be briefly outlined, as follows: It proceeds from a center in the medulla as far as the second dorsal nerve. It then follows the communicating branch of this nerve to the cervical sympathetic, and reaches the plexus around the internal carotid artery. From this point it passes to

12. Ophthalmic Surgery and Medicine, London, 1898.

the nasociliary branch of the nasal nerve, which as the long ciliary nerves supply the muscular tissue of the iris.

Collins and Onuf,[5] after comparing the results of various investigators, find that the pupillodilating fibers occur with the greatest constancy in the first dorsal and almost as constantly in the second dorsal, to less extent and less constantly in the third dorsal and the eighth cervical, and least constantly in the seventh cervical and fourth dorsal. This distribution varies, not only with the species of the animal, but also individually in the same species.

Experimenting in 1841, Budge and Waller[13] determined the origin of the pupil-dilating fibers of the cervical sympathetic to be in the spinal cord in a region situated between the exits of the sixth cervical and fourth dorsal or thoracic nerves. Since that time this center has been called Budge's center, or the ciliospinal center. Budge's conclusions have been both confirmed and denied, confirmed by Dastre and Morat, and denied by Salkowski and Knoll, the former placing the origin of the pupil-dilating fibers in the medulla, the latter in the anterior corpora quadrigemina. Referring to these contradictory statements, Collins and Onuf declare that although experimental as well as clinical evidence is in favor of the existence of a ciliospinal center, it has not been definitely proven.

Several observers, notably Francois-Franck, maintain that not all the pupil-dilating fibers are derived from the cervical sympathetic, but that some of them reach the gasserian ganglion by way of the roots of the trigeminal nerve, and this view, according to Onuf and Collins,[14] is confirmed by the results of their experiments. The possibility that the sympathetic may also contain pupil-contracting fibers is a subject to which reference will be made in another portion of this paper.

V. CONCERNING THE NATURE OF THE CILIARY GANGLION, WITH SPECIAL REFERENCE TO ITS RELATION TO THE SYMPATHETIC SYSTEM AND A CONSIDERATION OF THE EFFECTS ON THE EYE OF LESIONS OF THIS STRUCTURE.

The ciliary, ophthalmic, or lenticular ganglion, as it is variously called, is a center for the supply of nerves,

13. Vierordt's Archiv f. Physiolog. Heilkunde, 1852.
14. See Footnotes 2 and 5, pp. 91, 92, for experiments which these authors think demonstrate their belief.

motor, sensory and sympathetic, to the eyeball. This small, reddish body, composed of cells of the multipolar variety, is placed between the external rectus muscle and the optic nerve at the back of the orbit, and is joined from behind by branches from the trigeminus, the oculomotor and the sympathetic nerves. A slender filament derived from the nasal branch of the ophthalmic constitutes its long or sensory root, a twig from the branch of the third nerve going to the inferior oblique muscle, its short or motor root, and a small nerve from the cavernous plexus of the sympathetic, its middle or sympathetic root. Much difference of opinion has existed and still exists concerning the nature of this ganglion, i. e., whether it should be considered as a spinal, sympathetic, or mixed sensitivo-motor ganglion.

Schwalbe[15] believes that the ciliary ganglion is a spinal ganglion and belongs entirely to the oculomotor, a view which has also been maintained by Antonelli, and confirmed, in so far as its spinal nature is concerned, by Goldberg[16] in his researches on the embryo of chickens. Hess, Remak and Phisalix maintain the spinal nature of the ganglion and that it belongs to the trigeminus. Van Gehuchten, who, like Retzius and von Michel, has employed the Golgi method in his investigations, is inclined to a belief contrary to that of the authors just named, and thinks that the ciliary ganglion is to be reckoned with the spinal ganglia.

Peschel[17] found a diminutive ganglion, which is situated on the oculomotor of the rabbit, to be composed of cerebrospinal ganglion cells. In addition to this, however, he observed a well-developed system of sympathetic ganglion elements in the orbit which was subject to a great many variations, but was always demonstrable.

Holzmann[18] has histologically examined the ciliary ganglion in a number of animals, and found it of various composition—in frogs of spinal cells, in birds of cerebrospinal elements, in rabbits of the same structure, but also the widespread sympathetic elements in the orbit previously described by Peschel; in dogs great

15. Jenaische Zeitschr., Bd. xiii, 1879.
16. Archiv f. Mikroskopie, Bd. xxxvii.
17. Graefe's Archiv f. Ophth., Bd. xxxix, 2.
18. Morphologische Arbeiten, Bd. vi.

individual variations, as well in the position as in the structure of the ganglion, but with the sympathetic elements prevailing; and in cats practically entirely sympathetic cells, spinal elements being at most in the form of under-developed or pigmy cells.

Michel's[19] researches show that the ganglion in man and calves is a sympathetic structure. An interesting fact observed by Holzmann and Schmiedeberg is on the action of atropin on the different animals in correspondence with the different histologic structure of the ganglion. In those species of animal, namely, in which the ganglion is mainly or entirely composed of sympathetic cells, atropin produces the most marked paralysis of the iris and ciliary body, while in birds, in which the ganglion cells partake of the nature of cerebrospinal cells, there is practically no atropin action. Kölliker believes entirely in the sympathetic nature of the ciliary ganglion, and rests his belief on histologic studies, especially such as have been made by Rauber, Retzius and von Michel, according to which the ciliary ganglion is composed only of multipolar sympathetic cells, and, on the other hand, on the experiments of Langley and Anderson,[20] and Langendorff,[21] who believe it is a sympathetic ganglion.

Lodato,[22] who has experimented with dogs, affirms that the ganglion is composed partly of sympathetic elements and partly of cerebrospinal elements. This, according to him, is true for the dog and very probably for other mammalia, and consequently for man. In short, he believes it is a mixed ganglion, sensitivomotor in nature, in which the motor part naturally depends on the sympathetic and the sensitive part on the trigeminus. The double nature of the ganglion has also been maintained by Krause.

Bernheimer,[23] whose observations were made on the ganglia of apes and monkeys, and who gives a good summary of the previous literature on this subject, from which several quotations have been made, is unwilling to commit himself entirely, but doubts the pure

19. Trans. Eighth Intern. Ophth. Congress, Edinburgh, 1894, p. 195.
20. Journal of Physiology, vol. xii, 1894.
21. Pflueger's Archiv f. Physiologie, Bd. lvi.
22. Archivio di Ottalmologia, vol. vii, 1900; Abstract Annales d'Oculistique, T. cxxvi, 1901, p. 230.
23. Archiv f. Ophth., Bd. xlix, 1897.

sympathetic nature of the ganglion, while Bach's[24] researches indicate that the ciliary ganglion in all probability is of a sympathetic nature. Marina,[25] who has elaborately studied the neuron of the ciliary ganglion, concludes that the ciliary ganglion in apes very probably possesses few spinal and numerous sympathetic cells. Jegerow considered the ciliary ganglion homologous to a posterior root ganglion.

Bach[26] finds that injections of nicotin into the orbit of the cat cause paralysis of the sphincter of the pupil very quickly. Now, inasmuch as nicotin paralyzes only sympathetic nerve cells, this indicates the presence of such cells in the orbit, and naturally suggests the sympathetic nature of the ciliary ganglion, although it does not disprove the possibility of its being of a mixed nature.

Langendorff[27] formerly advocated the spinal nature of the ciliary ganglion, but as the result of recent investigations he has changed his opinion and now believes it to be a sympathetic ganglion.

It will therefore be seen from this imperfect résumé that the nature of this nervous structure has not been positively determined in any one species of animal, and that it differs greatly in different species. All things considered, however, the weight of evidence is in favor of the ganglion belonging to the sympathetic system, at least in so far as man is concerned. Assuming, therefore, the probable sympathetic nature of this structure, a few words may be said on its relation to the pupil movements. As is well known, Langley and Anderson have noticed that the erectores pilorum of the cat are under the influence of certain communicating rami of the anterior spinal roots, but that this influence is exerted not directly, but with the help of nerve fibers which arise in the ganglion of the sympathetic cord. In the same manner, according to the observation of these authors and according to the researches of Langendorff, the oculomotor nerve acts not directly on the sphincter of the pupil, but in association with the ciliary ganglion. According to Langendorff, electrical stimulation of the

24. Ibid., xlvii, 1899, p. 68.
25. Deutsch. Zeitschr. f. Nervenheilkunde, xiv, 1899, p. 356.
26. Bericht über die XXX Versammlung Ophthal. Gesellschaft. Heidelberg, 1902, p. 16.
27. Klin. Monatsbl. f. Augenheilk., xxxviii, 1900, p. 307.

trunk of the oculomotor of the cat in the cranial cavity never produces contraction of the pupil. Only when quite quickly after death it is stimulated, a distinct contraction proceeding from the oculomotor trunk can be observed. After a short space of time this result ceases to exist. If, instead of the oculomotor branch, the short ciliary nerves of the orbit are stimulated some time after death, it is still possible to obtain a pupil contraction. Langendorff concludes, therefore, that the myotic fibers of the oculomotor nerve do not traverse the ganglion uncombined, but that ganglion cells are inserted in the pupil-contracting path, early death of which is responsible for the failure of the irritation effect, which ought to follow the proximal stimulation of the nerve trunk.

Apolant,[28] writing concerning the nature of the ciliary ganglion, maintains that after section of the oculomotor in the skull, the degeneration of the entire oculomotor fibers in the ganglion can be traced only to the cells of the ganglion and not further on. This result he explains on the supposition that those root-fibers which belong to the oculomotor end in the ganglion, as von Michel has shown in Golgi preparations, and that with the cells of the ciliary ganglion a new neuron begins for the fibers which pass to the ciliary muscle and the sphincter of the pupil.

To put this matter in another form and using the words of Sherrington, the smaller root-cells of the oculomotor send their nerve fibers to the ciliary ganglion, whence, as from a sympathetic ganglion, fresh nerve cells emit fibers to the ciliary muscle and constrictor-pupillæ.

Marina,[25] after pointing out that there is much difference of opinion as to the exact position of the center of the pupil movements, for example, that Voelker and Hensen place the center in the anterior portion of the oculomotor nucleus, von Bechterew in the central gray matter of the third ventricle, Mendel in the ganglion habenula, and that in man the Westphal-Edinger and later the Darkschewitsch nucleus have been claimed as the center, although Bernheimer thinks that the last-named nucleus does not belong to the oculomotor group at all, and has nothing to do with pupil-reaction, maintains

28. Archiv f. Anat. u. Physiol., Physiologische Abth., 1896. p. 344.

that the ciliary ganglion is the center for pupil-movement. He agrees with Bernheimer that five-sixths of the cells of the ciliary ganglion degenerate after cauterization of the cornea, and that therefore five-sixths of these cells are of sensory nature and are active in the sensibility of the cornea. Nicotin experiments indicate that the sensory cells of the ciliary ganglion are of spinal nature. Opticociliary neurotomy and exenteration of the bulb, or, in other words, injury to those nerves which supply the intraocular muscles, cause all of the cells of the ganglion to be more or less degenerated. It follows, therefore, that the greatest part of the ganglion cells possesses a motor function, namely, the innervation of the sphincter of the iris, and he concludes, as before stated, that the ciliary ganglion, in apes at least, very probably contains few spinal and numerous sympathetic cells, and returns to his contention that the ganglion is really the center for pupil movements. Now Bernheimer,[23] also experimenting with apes, finds that there are roots of nerve fibers which supply not alone the ganglion cells but also the cornea, hence lesion of the ganglion, for this structure is alike in apes and man, ought to produce a corneal destruction as well as fixation of the pupil, if it really is, as Marina maintains, the center for pupil movement, an association which has not been observed. Otherwise it would be necessary to assume an elective primary disease of those cells which supply nerves to the iris and ciliary body, and this is exactly what Marina does, although Bernheimer is unwilling to agree with him. In this connection it is interesting to revert to the fact that many years ago ophthalmoplegia interna, that is, paralysis of the intraocular muscles, the iris and ciliary body, was ascribed by Jonathan Hutchinson to disease of the lenticular ganglion, and although it is customary to say at the present time that he was mistaken in this view of the pathology of these cases, if Marina's results are to be considered trustworthy, and his assumption of an elective primary disease of those cells which supply the iris and ciliary body be accepted, he was exactly right.

The effect of lesion of the sympathetic on the cornea has been given a new significance by Emil von Grosz.[29] If it is true, he argues, as the researches of Bernheimer

29. Ungarische Beiträge zur Augenheilkunde, Bd. ii, 1900, p. 295.

and others indicate, that fibers from the ciliary ganglion of apes go to the cornea, and if, further, it is true that the ciliary ganglion, according to its nature, belongs to the sympathetic, and that only trigeminus fibers pass through it, then the degenerated paths which have been demonstrated may be identical with the fibers which influence the nourishment of the cornea. It follows that it is reasonable to ascribe the cause of the neuroparalytic keratitis to disease of the ciliary ganglion, because only trigeminus fibers pass the ganglion, therefore section of the ganglion of Gasser or of the trigeminus is associated only with anesthesia and could produce no lesions in the ganglion or in the cornea. On the other hand, the sensitiveness of the cornea could be sympathetically affected if the ganglion was diseased, and this is actually the case. He believes, in other words, that the suppurative keratitis which occurs in the eyes of animals and men after section of the trigeminus or disease or injury to the gasserian ganglion is brought about by infection which comes from the conjunctiva, the lachrymal sac, or the external atmosphere and which is established because the anesthesia and drying of the cornea can not resist injuries, but that the cause of true neuroparalytic keratitis of men, which is identical with keratomalacia and keratonecrosis, is due to a degeneration of the cells of the ciliary ganglion which may occur from cachexia, hemorrhage or from injury. This view, however, is not substantiated from the experimental standpoint, inasmuch as Anderson,[30] who has extirpated the ciliary ganglion in kittens, never observed trophic changes.

Ordinarily excision of the ciliary ganglion increases dilatation of the pupil, and, as Jegerow[31] has shown, this dilatation is greater than after section of the nerve.

Anderson was able to obtain in kittens from which he had removed the ciliary ganglion a paradoxical pupilloconstriction of the denervated sphincter, just as after extirpation of the superior cervical ganglion in animals slight stimulation produces a paradoxical pupillary dilatation which has been attributed to increased tone in denervated unstriped muscle. Anderson, however, has shown that his observations on paradoxical pupilloconstriction were not to be explained by increased

30. Jour. of Physiol., vol. xxviii, No. 3.
31. Arch. Slaves de biol., Paris, 1887, T. iii, p. 322.

tone, but increased excitability brought about by very slight stimuli.

Finally, we come to consider what the effect on the tension of the eyeball is when the ciliary ganglion is extirpated, as it has been suggested that this operation might replace the one of excision of the cervical sympathetic ganglion in glaucoma.

Rohmer[32] has extirpated the ciliary ganglion in seven cases of absolute glaucoma, and although he claims that pain was ultimately alleviated, in all cases tension was never reduced to normal. In other words, as J. Herbert Parsons, commenting on this paper, has said, the results of Rohmer's work afford little support to the view that the increased intraocular tension of glaucoma is in any way associated with the ciliary ganglion. There is even less experimental evidence, as he further remarks, for this hypothesis than for that which attributes this function to the superior cervical ganglion. Rohmer believes that the ciliary ganglion controls the vascularization of the anterior segment of the eye, and the superior cervical ganglion that of the posterior segment, and in this manner each influences the intraocular tension.

VI. THE RELATION OF THE SYMPATHETIC TO ACCOMMODATION AND REFRACTION.

Morat and Doyon[33] maintain that after section of the sympathetic there is a diminution in the size of the anterior crystalline lens images, and after irritation of the sympathetic an enlargement of the same images. Therefore, they conclude that the sympathetic exercises an inhibitory influence on accommodation and has an antagonistic action to the third nerve. In other words, according to them, the sympathetic is an inhibitory nerve for the accommodation and influences its function at the distant point, the oculomotor, of course, adapting the eye for near objects. These observations have not been confirmed by Langley and Anderson or by Hess and Heine.[34] The latter observers, for example, found that if the sympathetic is exposed in a dog and a registering needle inserted into the equator of the eye, and the sympathetic irritated the pupil

32. Annales d'Oculistique, July, 1902.
33. Archiv de Physiol., vol. iii, 1901, p. 507.
34. Archiv f. Ophthalmol., xlvi, 1898, p. 259.

promptly dilates, but the needle remains quiet; in other words, the sympathetic can dilate the pupil, but does not influence the ciliary muscle. There is under these circumstances, sometimes, a diminution in refraction, which Hess and Heine attribute to the disturbing influence of the more peripheral portions of the cornea and lens, made possible by the dilatation of the pupil.

These views were contested by Dor at the meeting of the Thirteenth International Congress in Paris, and therefore Rohmer and Dufour[35] have returned to the subject and made numerous experiments, and endeavored especially to elucidate two points, namely, the alteration in the refraction which undoubtedly occurs after stimulation of the sympathetic and which may be demonstrated by retinoscopy and the change in the size of the images on the lens which Dor asserts takes place. They find that the alteration in refraction noted in certain instances on dilatation of the pupil is not necessarily due to any actual change in the lens and show that the difficulty of being quite certain of an increase of diminution in the size of the very small images on the surface of the lens is extremely great. Morat and Doyon state that the image may enlarge by as much as a third or even a half of its own diameter: now in man, at all events, an alteration in size of slightly less than half has been shown to correspond to a change in refraction of 7 D., much greater than the alteration in refraction admitted by Hess and Heine. Rohmer and Dufour do not, moreover, find that close relationship to exist between the pupil dilatation and the alteration in the size of the images on which the French observers have laid considerable stress. Indeed, their results are directly contrary to those of Morat and Doyon. In other words, they do not find that the sympathetic has any power of causing negative accommodation.

The effect of stimulation of the cervical sympathetic in rabbits on the refraction of the eye has recently been investigated by Terrien and Camus.[36] They found that stimulation of the cervical sympathetic after section induces in all cases an increase in the refraction of the eye on the same side, this increase varying from

35. Ibid., liv, Abth. 3; see, also, abstract Ophthal. Review, January, 1903.

36. Ibid., June, 1902.

1 to 2.05 D. This change in refraction does not coexist with the dilatation of the pupil, but begins later and is of shorter duration. The authors do not furnish a satisfactory explanation of the phenomena which they observed, although they eliminated the possibility of elongation of the globe or increase of corneal curvature being due to muscular action by cutting the external ocular muscles. Experiments with Purkinje's images to ascertain whether the refraction of the lens changed, gave no definite results.

VII. THE RELATION OF THE SYMPATHETIC TO INTRAOCULAR TENSION.

As long ago as the times of Pourfour de Petit, that is in 147, it was observed that after section of the sympathetic the eye was softer, and this fact was afterwards verified by Claude Bernard and other experimenters, and very early it was suggested that a primary disease of the sympathetic ganglia of the neck might be the basal cause of glaucoma. In 1867, Adamük,[37] and about the same time Wegner,[38] discussed the relationship between intraocular tension and the cervical sympathetic in the neck, and the influence of the latter on the development of glaucoma, although their experimental researches were not entirely in accord. Eulenberg and Guttman,[39] discussing this matter, have summarized the results of these observers somewhat as follows: Adamük found, after cutting the neck sympathetic in chloroformed cats, a diminution of the intraocular tension of 1 to 2 mm. This lessening was of short duration and it was soon followed by a supplementary elevation of tension. Irritation of the cut sympathetic with induction currents caused an elevation of intraocular tension of 2 to 4 mm., which remained for a time and then gradually disappeared. The diminution of the tension was coincident with the pupil enlargement and the exophthalmos, and was ascribed by Adamük to lessening of the blood-stream. The early elevation of tension he attributed to the accommodative apparatus. According to him, two factors were potent in the production of changes in the

37. Med. Centralbl., 1866, No. 36; Ibid., 1867, No. 28; Abstract Annales d'Oculistique, lviii, p. 5.

38. Archiv f. Ophthalmol., Bd. xii, Abth. 2, 1866, p. 1.

39. Die Pathologie des Sympathicus auf Physiologischer Gründlage. Berlin, 1873.

intraocular tension under the influence of irritation of the sympathetic which worked in opposite ways, and according as one predominated or did not predominate the tension rose or fell, the one factor, that is, the vasomotor apparatus, causing lessening of the intraocular tension, the other inherent in the internal ocular muscles, probably the ciliary muscle, giving rise to an elevation of intraocular tension.

Hippel and Grünhagen also observed that in the early stage of sympathetic irritation in cats there is an elevation and later a dropping of the intraocular tension. These results were explained by a contraction of the orbital muscles and the vessels of the eye. Elevation of the intraocular tension after irritation of the sympathetic was likewise noted by Francois-Franck.

Adamük, in disagreement with Hippel and Grünhagen, after excluding every possible error, satisfied himself that elevation of intraocular tension depended on contraction of the inner muscles of the eye, that is, of Müller's fibers of the choroid and perhaps a portion of the ciliary muscle. These sympathetically innervated muscles caused the bulb to start forward and in that manner an increase in the depth of the anterior chamber was determined. Irritation of the sympathetic in curarized animals, according to this observer, produced narrowing of the arteries and filling of the veins of the retina, and therefore he believed that the chief cause of glaucoma depended, not so much on an elevation of tension as on inhibition of the venous circulation which is induced when there is loss of the elasticity of the sclera as the result of inflammatory processes. Wegner also found diminution of intraocular tension, from 4 to 8 mm., after section of the sympathetic, which he attributed to a paralytic widening of the blood vessels.

Horner, and later his student Nicati,[40] writing concerning paralysis of the sympathetic from various pathologic conditions in the neck, noted a diminution in the tension of the eye which was present in two periods of the paralysis, that is, in the period which was analogous in his phenomena to those observed in animals after section of the cervical sympathetic, and in the period in which the symptoms were modified by secondary atrophies. Therefore it was concluded that this fall in

40. La Paralysie du Nerf Sympathique Cervical, 1873.

tension was independent of any excess of vascularization. Abadie, believing that the symptoms of glaucoma can be explained by an excitation of the vasodilator fibers of the ocular blood vessels, suggested in 1898 that relief from this disease might be obtained by section of the sympathetic in the neck, and soon afterward the first operation of resection of the cervical sympathetic was performed by Jonnesco.

In still more recent times numerous experiments have been made on the effect of irritation and section of the sympathetic on the intraocular tension. Thus Neuscheuler[41] has observed that narcosis itself causes an elevation of the intraocular tension of from 2 to 6 degrees in Fick's tonometer, while irritation of the sympathetic causes an elevation of at least 10 degrees. Section of the sympathetic reduces the tension on the same side from 3 to 6 degrees, but only after twenty to forty-five minutes. Observations of this character made in rabbits were confirmed in cats, who have a deeper anterior chamber, and it was further noted that in these animals irritation on one side caused an elevation of tension in the opposite eye.

Using the method of slow irritation of the cervical sympathetic, produced by inserting a small foreign body into the superior ganglion, Lodato,[42] by means of the Leber apparatus, studied the relations between secretion and excretion of the aqueous fluid in the eye on the same side as the irritated sympathetic, and proved that there was a diminution of the flow from the apparatus to the anterior chamber and therefore increased intraocular tension. He further demonstrated that this rise of tension is independent of dilatation or constriction of the blood vessels, inasmuch as he was able to note an increase of tension in cases of superficial and deep vasodilatation and vasoconstriction. Finally, he demonstrated that the increase of tension is absolutely independent of the state of the pupil. The increase of tension may last for several months in the dog, with but slight variation.

The result of excision of the cervical ganglion of the sympathetic on intraocular tension in rabbits has been investigated by Selenkowski and Rosenberg,[43] and while

41. Nagel's Jahresbericht f. Ophthalmologie, vol. xxx, 1899, p. 120.
42. Klin. Monatsbl. f. Augenheilk., xli, Bd. i, 1903, p. 329.
43. Nagel's Jahresb. f. Ophtalmol., xxxii, 1900, p. 603.

they found a reduction of intraocular tension, it was always exceedingly temporary in its effect, lasting sometimes only three to five days and never more than twelve days. They naturally contend, therefore, that Abadie's theory of glaucoma is untenable.

Hertel,[44] experimenting on young animals (ten to twenty day old rabbits) found a lowering of tension about one hour after excision of the ganglion, as determined by manometer and tonometer, but this lasted only five days. He thinks the varying results reported by observers may depend on the difference of time in noting tension, and believes there is a relation between vessel fullness, myosis and lowered tension. When the vessels return to their natural state and myosis lessens, tension returns to normal.

Levinsohn,[45] who has quite recently reviewed the entire subject of the influence of the cervical sympathetic on the eye, experimenting on apes and other animals, has noted that sympathetic section primarily diminishes the intraocular tension, which in a very short time returns to normal. A similar result was noted when only the large branches, but not the carotid branches, were cut, a fact which might indicate that the diminution in pressure was not only due to vessel but to muscle changes.

Joseph Collins[46] believes that the diminution of intraocular tension caused by extirpation of the cervical sympathetic depends on a reduction of the blood pressure and that this procedure acts on the blood vessels of the eye something as nitroglycerin does. In other words, he suggests that the diminution of intraocular tension must be dependent on the general dilatation that occurs in the carotid system after the ganglion has been extirpated.

VIII. THE OCULAR PHENOMENA WHICH FOLLOW GALVANIZATION AND FARADIZATION OF THE CERVICAL SYMPATHETIC.

To a certain extent these phenomena have already been discussed, but they may in general terms be referred to again in a summary manner. The effects which electrical currents when applied to the sympa-

44. Archiv f. Ophtalmol., Bd. xlix, 1900, p. 432.
45. Ibid., lv, 1902, p. 144.
46. Personal communication, March 19, 1903.

thetic produce must be studied in their relation to: (a) the pupil of the same side; (b) the contralateral pupil, that is, the pupil of the opposite side; (c) the color of the iris; (d) the position of the nictitating membrane and the globe of the eye and the width of the palpebral fissure; (e) the blood vessels of the conjunctiva, the iris and the fundus oculi; (f) the tension of the eyeball; (g) the secretion of the lachrymal gland.

1. Electrical stimulation of the cervical sympathetic produces on the side stimulated a dilatation of the pupil as a result of the contraction of the dilatator pupillæ. Whether this dilator should be regarded as a muscular structure or only as a contractile substance, or whether the phenomenon depends on inhibition of the sphincter has been thoroughly discussed and need not again be reviewed.

According to Lodato, if in the superior ganglion a foreign body is inserted, there is produced a slowly-acting state of irritation of the cervical sympathetic. The pupil dilates, but the dilatation is rarely a lasting one. Such a pupil reacts but slightly to the action of light, but if light is flashed into the opposite pupil, there is a reaction of the one on the operated side. In these cases there is a distinct grade of retinal anemia, to which Lodato attributes the pupillary phenomenon.

2. In 1893, Dogiel made the interesting observation that when the cervical sympathetic was stimulated on one side, there was on the opposite side a contraction of the pupil, and he explained this phenomenon by assuming that there was a physiologic connection with the pupil-dilating center of the one and the pupil-contracting center of the other side, although such anatomic connection had never been demonstrated.

Schenck and Fuss[47] have confirmed Dogiel's observation, but believe that in dogs and cats this result depends on the consensual pupil-reflex, inasmuch as the increased light impulse which enters the eye on the electrically irritated side, owing to the mydriasis which is produced, causes reflex narrowing of the pupil on the opposite side. In rabbits, in which there is no consensual pupil-reflex, they could not in opposition to the statement of Dogiel establish a narrowing of the contralateral pupil.

47. Archiv f. die Gesammte Physiol., lxxv, 1899, p. 110.

Tuemianzew[48] has investigated this subject most elaborately and believes that Dogiel's reaction is not produced by changes in the eye on the side of the irritated sympathetic, that it can not be considered entirely as the result of the consensual pupillary reaction, as maintained by Schenck and Fuss, but that it represents a newly discovered reflex, transmitted through the sympathetic fibers, joining the cranial nerves in the region of the cavernous sinus.

There would seem to be some difference in effect following galvanization and faradization of the sympathetic, if the observations, but so far as I know unconfirmed, of Katyschew[49] may be credited, which, briefly summarized, are these: Galvanization of the superior triangle of the neck may cause dilatation of the pupil, but also contraction, anodal opening producing a rapid dilatation, while cathodal closing is usually not associated with constant changes. If this region is faradized, the pupil contracts, either immediately or at some later date, contraction occurring on the side of the electrode, on the other side, or on both sides. He believes that through this faradization nerve fibers still unknown are irritated, which act as inhibitory fibers to those sympathetic nerves going to the pupil dilator. It is likely that they come from the spinal cord and pass through the carotid plexus.

3. The same observer has noted that after faradization and contraction of the pupil there is a change in the color of the iris, which he attributes to varying displacement of the iritic fibers. So far as I know, this observation has not been confirmed.

4. Electrical stimulation of the cervical sympathetic causes retraction of the nictitating membrane, which, according to Langley's observations, is much more prominently seen in the cat and dog than in the rabbit. In the higher animals, as in man and apes, the nictitating membrane is rudimentary. In addition to this, there is separation of the lids, the movement being greater in the lower than in the upper eyelid. Finally, there is well-marked projection of the eye, or proptosis; in other words, the direction of its axis being straight forward. Eckhard is of the opinion that this proptosis is more apparent than real, and is manifest chiefly because the

48. Ibid., lxix, 1897, p. 199.
49. Archiv f. Psych. u. Nervenkrank., vol. viii, 1877-78, p. 624.

lower eyelid is drawn decidedly backwards and therefore there is a greater exposure of the bulbus. This appearance is well marked in animals, especially dogs, and has also been observed by Wagner in the head of a decapitated criminal. There is no doubt that such phenomena depend on the action of the unstriped muscle in the region already described, in so far as animals are concerned. It is perhaps not so well established in human beings.[50]

Curiously enough, Heese[51] has found that irritation of the sympathetic causes in rabbits, in contrast to the general rule, a retraction of the eyeball into the orbit, and this is due to a contraction of the orbital vessels and the anemia which is thereby caused. In other words, the sympathetic nerve displays its effect on the eyeball in two different ways, that is, by a contraction of the unstriped muscles of the orbit, Müller's muscle, and by vasomotor influence. If Müller's muscle contracts there is protrusion, but if there is a contraction of the orbital vessels, then there is a sinking in; predominance of the one influence will cause exophthalmos, predominance of the other, enophthalmos.

5. Stimulation of the cervical sympathetic is followed by contraction of the blood vessels of the conjunctiva, of the iris, and perhaps by alteration in the caliber of the vessels of the retina, although it is difficult to get satisfactory evidence with reference to the last-named phenomena.

Rockwell and Beard[52] investigated the effect of galvanization of the sympathetic on the vessels of the eyeground, using a current of from 10 to 25 elements. Roosa, who watched the retina under these circumstances, saw at first a hyperemia and afterward an anemia of its vessels, while Loring noted only decided filling of the veins, and another observer only contraction of the arteries. Slow-acting mechanical irritation of the sympathetic, according to Lodato, produces retinal anemia in dogs.

6. The effect of electrical currents on the tension of the eyeball, when these were applied to the cervical sympathetic, as well as their influence in increasing the secretion of the lachrymal gland, have already been detailed.

50. Consult Die Neurol. d. Auges, Wilbrand and Saenger, i, p. 545.
51. Archiv f. die Gesammte Physiol., Bd. 52, 1892, p. 535.
52. Medical and Surgical Electricity, 1871.

IX. THE OCULAR PHENOMENA WHICH FOLLOW INJURY TO THE SYMPATHETIC IN THE NECK CAUSED BY DISEASE OR BY SECTION OF THE SYMPATHETIC CORDS, OR BY THE EXTIRPATION OF THE SYMPATHETIC CERVICAL GANGLIA.

In connection with this subdivision of the subject, we have to study: (a) The condition of the pupil; (b) the width of the palpebral fissure; (c) the position of the nictitating membrane; (d) the position of the ocular globe; (e) the state of the conjunctival blood vessels and the secretion of the lachrymal gland; (f) the intraocular tension; (g) alterations in the vascular supply of the uveal tract and the retina; (h) trophic changes in the globe; (i) the shape of the cornea, and in general, the refraction of the eye.

It is well known that the sympathetic nervous system exercises a tonic action on certain of the structures which it supplies; for example, in the cervical sympathetic, the vasoconstrictor fibers, the pupillodilator fibers and the constrictor fibers to the unstriped muscle of the eye and its appendages, are, to quote the words of Langley, in a state of constant action, broken only by a state of inhibition, occurring in the central nervous system; hence section of the cervical sympathetic will cause a paralytic effect in those tissues which are in a state of tonic contraction.

(1) As long ago as 1727, Pourfour du Petit noted that division of the cervical sympathetic was followed by contraction of the pupil, and this observation was confirmed particularly by the studies of Claude Bernard in 1851, and later by those of Brown-Sequard in 1852. All subsequent experiments, as well as clinical observations, which indicated that the cervical sympathetic had been destroyed by injury or disease, have confirmed these results, and we now know that when the mydriatic path in the sympathetic, that is, the path which contains the pupillodilator fibers, is divided, there is necessarily prompt contraction of the pupil on the corresponding side.

A matter of some interest is to determine whether the effect on the pupil, as well as the other structures of the eye, is greater after excision of the superior cervical ganglion than after section of the sympathetic cord. Claude Bernard noted greater paralytic results from excision than from section, but Schiff, Callenfels

and Pye-Smith failed to find any difference. This question has been recently investigated from the experimental standpoint by Levinsohn,[53] and he has found, experimenting with apes, that if the sympathetic is cut on one side and the ganglion removed in the other, the difference in the pupillary width is not very great, amounting to no more than ½ mm., but in cases where, respectively, the sympathetic is cut or the ganglion removed, the pupillary difference is demonstrable and the pupil always smaller on the side on which the ganglion is removed. This of itself is not sufficient evidence to declare that the ganglion exercises an individual tonus over the nerve, but when the ganglion is removed, the nerve having previously been resected, additional contraction takes place, and this, it would seem, indicates that the ganglion has a different and, as it were, a stronger action on the eye than the nerve trunk itself. Furthermore, irritation in some animals of the peripheral cut ends of the nerve trunk causes no additional change in the pupil, and the same occurs when the lower part of the ganglion is irritated. Excitation of the upper part of the ganglion, however, produces a prompt response, and therefore the indications are that an individual tone is exercised by the ganglion. The tonus remaining in the ganglion is dependent on higher cerebrospinal twigs. Langendorff believes that the superior cervical ganglion possesses a distinct tonic activity.

A matter of great importance is the permanence of the myosis after section of the sympathetic or extirpation of the ganglion. According to Langley, this varies greatly in different animals. In the frog the development of paralytic symptoms in the eye after section of the sympathetic is gradual; in the rabbit after twenty-four hours the pupil begins to dilate, and on the third to the fifth day again becomes small and remains smaller than normal; in all animals there is some degree of return to normal after section. In the cat and dog section of the cervical sympathetic causes a permanent diminution in the size of the pupil; in the rabbit this phenomenon is much less marked. Levinsohn has also noticed that the myosis, as well as the other paralytic symptoms, gradually becomes less apparent but

53. See footnote 45; also, Bericht über die XXX Versammlung der Ophth. Gesellschaft, Heidelberg, 1903, p. 238.

does not entirely disappear, and long ago Pye-Smith observed that permanent contraction of the pupil was more nearly a result without exception than the other phenomena.

Langendorff[54] maintains that myosis produced by excision of the cervical sympathetic, as well as the accompanying narrowing of the palpebral fissure and retraction of the globe, may persist for years. After extirpation of the superior cervical sympathetic ganglion all the phenomena of paralysis of the sympathetic nerve, especially contraction of the pupil, are at first pronounced. These phenomena, however, gradually become less marked, and may disappear or even give place to the opposite condition. This change to the opposite condition always occurs when the animal is anesthetized, several days, or weeks, or months after the operation, or when it is subjected to sensory or emotional stimuli. It is possible that dyspnea also may have the same effect. Putting this in another way, it may be stated, according to Langendorff, that following extirpation of the upper cervical ganglia the phenomena of sympathetic paralysis which appear on the corresponding side soon after the operation may after a time disappear and give place to the signs of sympathetic excitation, which, although moderate, become very pronounced under anesthesia.

It would seem to make no difference in regard to the age of the animals experimented on, and within the limits already expressed, the species of animal employed. Extreme narrowing of the pupil, for example, has been seen by Hertel after the removal of the ganglion in young animals (ten to twenty day rabbits), and although the other symptoms were more or less transient, the myosis was permanent, but as time went on it also ceased to be as complete as immediately after section. Not only is there myosis when the ganglion is removed and the cord cut, but the same result may be obtained, as Levinsohn has shown, when the main branches are divided, but neither the main trunk or the secondary branches are injured. The myosis, however, is less marked under these circumstances than when the trunk is divided or the ganglion extirpated.

As has been already mentioned, Francois-Franck taught that not all pupil-dilating fibers contained in the

54. Klin. Monatsbl. f. Augenheilk., xxxviii, 1900, p. 129.

first branch of the trigeminal nerve are derived from the cervical sympathetic, but that part of them reach the gasserian ganglion by way of the roots of the trigeminal nerve, and Onuf and Collins are also convinced that not all the mydriatic fibers are contained in the cervical sympathetic.[55]

Although section of any portion of the mydriatic tract produces myosis, it does not abolish the pupil reflexes, that is, the pupil on the operated side will respond to light stimuli. Naturally, however, the so-called sympathetic reaction of the pupil, that is, the pain or the skin reflex, is abolished. Heiligenthal,[56] discussing cases in which the sympathetic had been destroyed by diseased glands in the neck, suggests that in the neck sympathetic fibers exist which produce a widening of the pupil as the result of psychic impressions.

According to Levinsohn,[53] the myotic pupil caused by sympathetic section or gangliectomy is not affected by the action of cocain. It is slightly contracted by eserin, but less contracted on the operated side than on the non-operated side. It is dilated by homatropin, the action being slighter on the operated side than on the other, owing to the smaller size of the pupil on the operated side and to the damaged tone of the dilator. He has further shown that not only is the action of these drugs less marked on the operated eye, especially in so far as eserin is concerned, but that it is slower than normal. Furthermore, the diminution in reaction is greater when the ganglion is resected than when the nerve is cut. These facts he thinks prove that the sphincter is weakened by the sympathetic operation, although what connection the sphincter has with the sympathetic nerve is not as yet known. Chloroformization of animals on whom sympathectomy has been performed causes a greater dilatation of the pupil on the operated than on the normal side. Gangliectomy produces a narrower pupil than sympathectomy, although the reverse was present before narcosis. Deep narcosis is necessary to bring about these changes. When intense narcosis is induced, this paradoxical pupillary change is more noticeable after the animal has somewhat recovered from

55. See footnote 14 for their experiments and for their belief that the sympathetic nerve contains not only the dilator but also contracting fibers for the pupil, that is, contracting fibers for the pupil of the same side.

56. Archiv f. Psych. u. Nervenkrank., 1900, p. 79.

the anesthetic. The normal pupil returns to its normal narrow state; the other remains dilated. Curare produces dilatation of the pupil on the operated side in rabbits, in monkeys less dilatation on the operated than on the normal side, and in cats greater dilatation on the operated side as compared with the non-operated side. This action is due to paralysis of the nerve supplying the sphincter.

Langendorff,[54] writing concerning the paradoxical pupillary dilatation, that is to say, that the myosis which follows gangliectomy is greater than that which succeeds sympathectomy, but that this condition is true only for a period immediately succeeding the operation, inasmuch as a few hours later the difference begins to disappear, and after one or two days the pupil on the side on which gangliectomy has been performed may even be larger than that on the side on which sympathectomy has been effected, summarizes the various theories which have been advanced to explain this condition, as follows:

(a) The oculomotor nerve meets with less resistance than ordinarily in the performance of its functions. This reacts on the focus where the nerve force is generated. In other words, the condition represents an example of the truth that power is increased by exercise and diminished by lack of resistance (Budge).

(b) Direct irritation of the dilator muscle by the drug used for the purpose of demonstration, for example, an anesthetic or atropin.

(c) Vasomotor changes.

Langendorff objects to all of these theories, and for his arguments the reader should consult the original. His own theory is that the explanation of the paradoxical pupillary phenomenon and associated phenomena depend on the degenerative processes in the postcellular nerves of the ganglion. He assumes that in the smooth muscles which, owing to their sluggish contractions, are probably not capable of fibrillary twitching, degeneration of their respective nerves may lead to irritative phenomena manifesting themselves in contractions or contractures. If such contraction may be assumed to take place after the removal of the upper cervical ganglion in the radial fibers of the iris muscle, which is the dilatator of the iris, and in the remaining unstriped muscles of the eye supplied by the cervical

sympathetic, the phenomena which have been described can be explained.

A considerable excision of the sympathetic must be made in order to prevent a rapid regeneration, and it has been shown that this regeneracy is moderately rapid in the cervical sympathetic and doubtless in other preganglionic sympathetic fibers. Langley states that he has found a return, although not to a full extent, of all of the functions of the sympathetic in a cat twenty-four hours after section, and Langendorff[57] has removed the superior cervical sympathetic ganglion from animals, and noticed restoration of function at the end of 105 days. The bearing of these facts on operative work on the cervical sympathetic is only too apparent.

2-4. From the earliest days of experimentation on the sympathetic to the present time, it has been noted that section of the cervical sympathetic, or its destruction by disease or injury, in addition to myosis, will be followed by narrowing of the palpebral aperture, projection of the nictitating membrane and retraction of the globe of the eye.

The narrowing of the palpebral fissure has been attributed partly to a predominating tonus of the orbicularis, partly to individual weight of the upper lid, and partly to a moderate retraction of the bulbus, brought about by a relaxation of Müller's orbital muscle, or by consecutive atrophy of the orbital fat. Like the myosis, it is more prominent after gangliectomy than after sympathectomy, but is not so permanent a phenomenon. The tone of the muscles, according to Levinsohn, injured by removal of the sympathetic is not completely destroyed, and under certain circumstances these muscles, especially in some animals, may acquire an increased irritability. When cocain is instilled under these circumstances, the same author has demonstrated that although the pupil is unaffected, the palpebral fissure is slightly widened, but after the ganglion is removed cocain produces change neither in the pupil nor in the width of the fissure. This narrowing of the lid fissure produces in effect a form of ptosis, sometimes called ptosis sympathica, first described clinically by Horner[58] and attributed by him to paralysis of the unstriped muscular fibers of the lid, the so-

57. Abstract, Lancet, Oct. 5, 1901.
58. Klin. Monatsbl. f. Augenheilk., vol. vii, 1869, p. 193.

called palpebral muscles of Müller, an explanation which has been adopted by many other writers and particularly insisted on by Nicati in his well-known monograph on paralysis of the sympathetic nerve. The slight ptosis after sympathetic palsy, according to Wildbrand and Saenger, manifests itself particularly after psychic alterations and physical exertions.[59]

Inasmuch as stimulation of the cervical sympathetic produces retraction of the nictitating membrane, it is natural that its paralysis or division will cause a projection of the same structure, a phenomenon which is interesting in animals, but not particularly noteworthy in men on account of the rudimentary nature of this structure. The retraction of the globe which follows sympathetic section has been attributed to a reduction of the volume of the bulbus, as was originally maintained by Pourfour du Petit and Claude Bernard, based on observations on animals who had survived some time after sympathectomy; to atrophy of the fatty tissues of the orbit; and finally, to paralysis of the smooth muscles which stretch across the floor of the orbital cavity.

Hertel,[44] experimenting on young rabbits, attributes this enophthalmos to atrophy of the orbital fat, and not to a paralysis of Müller's muscle, which he maintains comes on only at the end of six weeks. He believes that the elastic fibers in Müller's muscle are sufficient to hold the globe in place. Angelucci and others, like the earlier experimenters, have attributed this enophthalmos to a real smallness of the eye, that is, to an atrophy of the ocular globe, a position which later experimenters, notably Hertel and others, have not admitted to be established.

5-7. The state of the blood vessels of the conjunctiva and the iris and the secretion of the lachrymal gland under the influence of sympathetic section have been fully described and need not be referred to again. The same may be stated in regard to intraocular tension, to which a special paragraph has been devoted.

8. Ophthalmoscopic and microscopic lesions in the

59. Those interested in the clinical study of this question should consult the admirable work of Wildbrand and Saenger (see Note 50), pp. 541-558. It is interesting to remember that the first accurate study of bullet wound of the sympathetic and the classical symptoms it caused was made during our Civil War by Drs. Weir Mitchell, George Morehouse and W. W. Keen.

eyeground after sympathetic section have received considerable study. As long ago as 1871 Sinitzin[60] found, after extirpation of the superior sympathetic ganglion, an increased vascular injection of the eyeground on the operated side. He noticed that the choroidal vessels increased in volume, that their anastomoses were more readily seen, and that, in general terms, the redness of the eyeground on the operated side was greater than that on the opposite side.

Angelucci,[61] after extirpation of the stellate ganglion in the new-born dog, described lessening in the development of the circumference of the cornea and sclera; also atrophy and sclerosis of the texture of the iris and choroid and the formation of sclerotic plaques. He did not, however, discover fundamental changes in the structure of the retina. These dystrophies Angelucci attributed to changes in the blood vessel walls, which had already been described by Vulpian and Giovanni. Obarrio has reported hemorrhages in the ciliary body and ciliary processes and less frequently in the retina and choroid. These phenomena Hertel, who quotes them, could not substantiate in his experiments. Neuscheuler noted ophthalmoscopically vessel contraction during the period of sympathetic irritation and elevated tension, and the opposite condition during the period of section. After sympathectomy he observed widening of the blood paths of the uveal tract, as well as miliary hemorrhages, and naturally suggests that therapeutic extirpation of the sympathetic ganglion from this standpoint, at least, is not a harmless procedure.

Doyon,[62] writing concerning trophic disturbances of the eye after section of the great sympathetic in the neck, states that in rabbits this operation causes lesions of the lid and cataract, and points it out as interesting that the development of these trophic changes took place after section of a centrifugal nerve, although the general conception is that a lesion of sensitive nerves should be made responsible for such conditions.

Lodato[63] has studied the alterations in the retina which occur after excision of the superior cervical ganglion, his investigations being confined to dogs and rabbits,

60. Med. Centralbl., 1871, Nr. 11.
61. Boll. d. R. Acad. di Roma, vol. xix, 1892-93, p. 240.
62. Abst., Zeit. f. Augenheilk., 1899, i, p. 89.
63. Abst. Annal. d'Oculist., cxxvi, 1901, p. 229.

and has found that after ablation of the ganglion changes occur which are localized exclusively in the retinal ganglion cells. These lesions are slight and completely repair themselves in the rabbit; in the dog they are graver and last longer. With regard to the optic nerve, he believes that the degenerated fibers which have been found after extirpation are not really of a sympathetic nature, but are fibers which have been degenerated owing to alterations in the ganglion cells of the retina.

It will be remembered that Angelucci thought that the enophthalmos was due to an actual smallness of the globe, that is, to an atrophy of it; indeed, he maintained that after sympathetic section or ganglionectomy a form of microphthalmos developed. This change Hertel in his later experiments on young rabbits was unable to demonstrate. Levinsohn,[53] referring to trophic changes after ganglionectomy, found that the weight of the eyes was about the same on the operated and the non-operated sides. Indeed, there were no very constant alterations, the surest one being a greater filling of the choroidal vessels on the operated side, and the anterior part of the eye seemed smaller on this side. The sphincter in all cases where the sympathetic ganglion was removed, or the capital branches cut, was longer and narrower than on the other side; where the sympathetic was resected, the sphincter was shortened. Gatti[64] finds that osmosis at the lens does not alter for a time (three to fifteen days) after section of the sympathetic, but frequently loss of weight is evident.

The relation of the ciliary ganglion to trophic changes and the experiments of Bernheimer, Marina and others, and the idea of Grosz on the etiology of neuroparalytic keratitis, have been described.[65] Curiously enough, many years ago, the relation of the cervical sympathetic to neuroparalytic ophthalmia was studied by Sinitzin, who thought the cornea on the sympathectomized side was more resisting than that on the non-operated side to foreign substances, for example, bits of glass, inasmuch as on the normal side corneal ulceration always occurred under these circumstances, but not in the other eye. If the trigeminus was cut in the cranium, the neuroparalytic

64. Abst. Jahresb. f. Ophthal., 1898, p. 272.

65. Bach thinks that Bernheimer's cauterization of the cornea produced changes in the iris and ciliary body which were responsible for the degeneration set up in the ciliary ganglion.

phenomena did not appear in the eye if not long before this operation, or shortly afterwards, the upper cervical sympathetic was excised. He believed that the increased filling of the blood vessels caused by the operation, and on that account the elevation of temperature, played the important rôle of inhibitory agents.

9. Claude Bernard, Brown-Sequard and others believed that the cervical sympathetic had an influence on the shape of the cornea and described flattening of this structure after sympathectomy. Heese, however, was unable to find any alteration in the cornea and lens under these circumstances, and doubted whether the sympathetic had an inhibitory action on accommodation; in fact, according to him, it takes no part in the process at all. Eulenberg and Guttman[39] believed that the myosis was accompanied with myopia, which in its turn was dependent on a spastic state of the accommodation, but Nicati in his cases of palsy of the sympathetic was unable to find any effect which this lesion could have upon visual acuity, nor was he ever able to discover any influence on accommodation, and he disputes the contention of Eulenberg and Guttman that myopia ought to be a consequence of paralytic myosis. A detailed reference to the influence of the sympathetic on accommodation, and therefore on refraction in general, has been given and the subject need not further be discussed.

Before finally leaving the subject of the ocular phenomena which follow section of the cervical sympathetic or extirpation of its ganglia, reference should be made to the interesting observations of Dupuy.[66] This experimenter found that ptosis, retraction of the globe, advancement of the nictitating membrane and myosis after section of the cervical sympathetic all disappear if the restiform body is punctured on the side corresponding to that on which the lesion in the sympathetic has been established. In other words, puncture of the restiform body produces just the opposite effects of destruction of the sympathetic, and these effects, moreover, can be transmitted in animals from one generation to another, or, as Dupuy expresses it, transmitted through heredity.

X. EFFECT OF DRUGS AND TOXIC AGENTS ON THE SYMPATHETIC.

The scope of the present paper and the time at my disposal do not permit more than a very brief reference

66. Compt. rend. de la Soc. de Biol., vol. Jubilaire, 1899, p. 246.

to this very interesting subject. Reference may first be made to the exceedingly interesting work of Langley on the influence of nicotin on the activity of ganglionic nerve cells.[67] He found that in certain animals, for example, the rabbit, cat and dog, after nicotin injections into a vein, electrical stimulation of the cervical sympathetic on the proximal side of the superior cervical ganglion failed to produce any secretion of saliva; nor was he able to induce secretion under these circumstances if the electrode was applied to the ganglion itself. On the other hand, if the electrical stimulus was applied to the nerve fibers between the ganglion and the gland, active secretion was at once established. The natural inference from this experiment is that the nicotin interferes with the passage of secretory impulses, and that this interference is in the ganglion cells themselves. He further established his position by painting the superior cervical sympathetic ganglion with nicotin and again checked the passage of the secretory impulses, but when the nerve coat itself was painted instead of the ganglion, no interference in the stimuli occurred.

Pursuing his studies still further, Langley proved that when an animal was under the influence of nicotin, the cells of the ciliary ganglion were so affected that they formed, to use the technical expression, a "fault" in the transmission of the impulses to the sphincter of the iris, and in the same manner a fault in the transmission of the dilator impulses was obtained. In brief, Langley's experiments proved that nerve impulses, whether they be motor to striped or unstriped muscle, secretory, vasomotor or inhibitory, were all arrested in a nicotinized animal, provided these impulses were obliged to traverse ganglion cells. This important observation of Langley has been much used in physiologic experiments, and it is the custom now of this distinguished experimenter, as well as others who have followed in his footsteps, to utilize nicotin in the manner already described if they wish to ascertain if impulses pass along nerve fibers directly or only by synapse through the cells of a ganglion. If impulses such as have been described fail to pass in a nicotinized animal, it is quite certain that ganglion cells are in the path, and form, to use the expression previously used, a fault.

67. Trans. Royal Soc. and Jour. of Physiology.

We are especially indebted to Walter Jessop[68] for interesting observations on the action of cocain on the sympathetic. Shortly after the discovery of this alkaloid, he noted the enlargement of the palpebral fissure and the apparent prominence of the eye which followed instillation in the conjunctival cul-de-sac of solutions of cocain, and satisfied himself by a series of experiments, which have often since been confirmed, that this widening of the palpebral aperture was due to a stimulating or irritating action of the drug on the sympathetically-supplied unstriped muscular fiber of the lids, to which reference has so frequently been made in this paper. If cocain in 4 per cent. solution is instilled into the conjunctival cul-de-sac, as we all know, the pupil dilates. This dilated pupil will respond to strong light stimulus and to accommodation, is neutralized by eserin or pilocarpin, and still further widens under the influence of atropin. Numerous experimenters, notably Jessop, Limbourg and others, have shown that this mydriasis can not be due to paralysis of the peripheral endings of the oculomotor nerve, because the mydriasis is larger than that after section of the third nerve. Moreover, the pupil acts to light and to accommodation, and pilocarpin, which acts alone on the nerve endings of the oculomotor, produces myosis. Neither does the drug paralyze the sphincter of the pupil because the action to light and accommodation is retained, and eserin, which directly stimulates the muscular fibers, causes contraction. Finally, it has been noted that the mydriasis produced by irritation of the sympathetic is exactly like that which follows the instillation of cocain, and therefore it has been reasoned, on good grounds, it would seem, that cocain-dilatation of the pupil is due to a stimulant action of the drug on the mydriatic nerve endings, that is to say, on the sympathetic.

The physiologic action of the mydriatic alkaloids, especially of those which belong to the series of tropins, is of great interest, but only a brief reference can be made to them in so far as their action on the sympathetic nerve is concerned.[69] The dilatation of the

68. Trans. Ophth. Soc. U. K., vol. v, 1885, p. 240; Ibid., vol. vi, 1886, p. 123.

69. Those interested in this subject may consult H. C. Wood. Therapeutics. Its Principles and Practice, eleventh edition, 1900. pp. 175-177; H. C. Wood, Jr., The Physiologic Action of the Mydriatic Alkaloids, THE JOURNAL of the A. M. A., Feb. 21, 1903.

pupil caused by atropin is not centric in its origin, but depends on a peripheral action of the drug. Numerous experiments and the character of the mydriasis have led to the belief that the dilatation is due to palsy of the oculomotor endings and at the same time to a stimulant action of the drug on the sympathetic nerve fibers, or perhaps to a general paralysis of the unstriped pupillary muscle.

Although it is usually stated, and it seems to me with entire accuracy, that the myosis which is produced by the instillation of eserin is due to a stimulant action of this drug on the muscular fiber, some distinguished authorities, notably H. C. Wood, believe that the drug paralyzes the peripheral sympathetic nerve endings in the iris, although we know when there is complete paralysis of these nerve endings after gangliectomy or sympathectomy, eserin still further contracts the pupil, which would at least strongly indicate that this action is not on nerves, but on muscle fiber itself.

Recent experiments by S. J. Meltzer and Clara Meltzer[70] on the relation of the innervation of an organ to the influence of suprarenal extract on it, have developed some interesting facts. It is well known that intravenous injections of suprarenal capsule cause dilatation of the pupil, which lasts a very short time—less than a minute. Now the Drs. Meltzer have observed that when the sympathetic is cut a subcutaneous injection of adrenalin causes a dilatation of the pupil on the operated side which can last an hour and longer, and still further noted as remarkable that this effect does not take place if the injection is tried on the day of the operation. Ordinarily, instillation of this drug in the conjunctival sac produces no effect on the pupil, but when the sympathetic is cut, its instillation will cause a dilatation of the pupil lasting for some time. In other words, this substance exerts, ordinarily at least, no effect on a normal organ, in this instance the iris, but does exert a very considerable effect, and of long duration, if this tissue is deprived of some portion of its nervous control. Later experiments by Dr. S. J. Meltzer[71] are interesting as showing a difference in the effect between the removal of the sympathetic ganglion and simple section of the cervical sympathetic nerve. Subcu-

70. American Medicine, Feb. 7, 1903.
71. Personal communication, March 16, 1903.

taneous injection of adrenalin, or instillation into the conjunctival sac, causes a dilatation of the pupil on the side where the ganglion is removed, and not on the side where the sympathetic has been cut, the ganglion remaining intact—again an interesting confirmation of work which has several times been referred to in this paper of a difference in the effects of gangliectomy and sympathectomy, differences which may be well taken into consideration when the surgical side of the question is considered.

CONCLUSIONS.

From this review of the literature and the various opinions of the authors which have been quoted, the following conclusions may be drawn:

1. Although lachrymal secretion may be caused by excitation of the sympathetic, and increased lachrymation by section of the cervical sympathetic or removal of the superior cervical ganglion, the sympathetic itself should not be considered the nerve of secretion for the lachrymal gland.

2. Dilatation of the pupil is probably caused by contraction of a set of radially arranged muscular or contractile fibers, the so-called dilatator pupillæ, which is supplied by the sympathetic, and by inhibition of the sphincter of the iris. The dilating impulse transmitted to the iris passes through the cervical sympathetic and in general terms along the mydriatic tract of the pupil, which proceeds from a center in the medulla as far as the second dorsal nerve, follows its communicating branch to the cervical sympathetic, and arrives at the internal carotid plexus, from which point it passes to the nasociliary branches of the nasal nerve, which as the long ciliary nerves supply the muscular tissue of the iris.

3. Although experimental and clinical evidence favors the presence of a center situated between the spinal cord and the exits of the sixth cervical and fourth dorsal nerves, to which Budge relegated the origin of the pupil-dilating fibers of the sympathetic, its existence has not been definitely proven.

4. Although the nature of the ciliary ganglion has not been positively determined in any one species of animal, and, although it differs greatly in different species, the weight of evidence is in favor of the ganglion belonging to the sympathetic system, at least in so far as man is concerned. The root fibers which belong

to the oculomotor end in the ciliary ganglion, where a new neuron begins for the fibers which pass to the ciliary muscle and the sphincter of the pupil, i. e., the oculomotor does not act directly on the sphincter of the pupil, but only in association with the ciliary ganglion. There is a certain amount of evidence that this ganglion is related to the pupil movements in the form of a center, and it probably contains cells which are active in the sensibility of the cornea, but lesions of the ganglion itself, although they have been considered by Grosz to be the basal cause of true neuroparalytic keratitis, have not been proved to sustain this position by experiments, inasmuch as trophic changes have not been observed after extirpation of the ganglion. Removal of the ganglion has little or no influence on intraocular tension, and its excision is not a rational procedure for the relief of glaucoma.

5. There is no satisfying evidence that the sympathetic is related to the function of accommodation, and it has not been proved that the sympathetic has any power in causing negative accommodation, nor has it been demonstrated that alterations in refraction noted after stimulation of the sympathetic are due to actual change in the lens.

6. Electrical stimulation of the cervical sympathetic produces at first an increase and later a decrease of intraocular tension, the increase being probably due to an effect on the vessels of the eye. Slow-acting, mechanically produced irritation of the sympathetic causes a rise of tension, which, according to Lodato, is independent of dilatation or constriction of the blood vessels, and also independent of the state of the pupil. Section of the sympathetic, or extirpation of the sympathetic ganglion, is followed by a fall of intraocular tension, which probably depends on vascular and, perhaps, muscular changes. The lowering of tension is more decided after excision of the ganglion than after section of the sympathetic cords, but in either case the effect is a temporary one, and may not last more than a few days, and sometimes disappears within a few hours.

7. Electrical stimulation of the cervical sympathetic produces on the side stimulated a dilatation of the pupil as a result of contraction of the dilatator pupillæ, associated, perhaps, with an inhibition of the sphincter. At the same time there may occur on the opposite side

a contraction of the pupil, which either depends on the consensual pupil reflex, or represents a reflex transmitted through the sympathetic fibers joining the cranial nerves in the region of the cavernous sinus.

8. Electrical stimulation of the cervical sympathetic causes retraction of the nictitating membrane and proptosis, owing to the action transmitted to the unstriped muscular fiber. In contrast to the general rule, irritation of the sympathetic in rabbits causes a retraction of the eyeball in the orbit, which has been attributed by Heese to a contraction of the orbital vessels and the anemia which this causes.

9. Electrical stimulation of the cervical sympathetic is followed by contraction of the blood vessels of the conjunctiva and of the iris, and perhaps by alteration in the caliber of the vessels of the retina, although observations on the last-named phenomenon have been extremely contradictory.

10. Stimulation of certain areas of the brain cortex causes dilatation of the pupil, associated, if the cervical sympathetics are intact, with all the symptoms of stimulation of the cervical sympathetic. Division of the sympathetic stops the other symptoms, but not the dilatation of the pupil which is supposed to be due to inhibition of the tonic action of the third nerve (Parsons).

11. Sympathectomy or gangliectomy causes the following effects: Myosis, narrowing of the palpebral aperture, projection of the nictitating membrane, retraction of the globe of the eye, hyperemia of the vessels of the conjunctiva, increased lachrymal secretion, diminished intraocular tension, certain ophthalmoscopic and microscopic lesions in the eyeground, and possibly trophic disturbances.

12. The symptoms of sympathetic section or paralysis lessen after a time, myosis being the most permanent, lasting sometimes for years. The degree of permanence, however, of the paralytic phenomena varies much in different animals.

13. Myosis is greater after excision of the cervical sympathetic ganglion than after section of the sympathetic cord, because it is probable that a certain tone is exercised by the ganglion; that is, that it has a different, and, as it was, a stronger action on the eye than the nerve trunk itself (Levinsohn).

14. All the phenomena of paralysis of the sympa-

thetic nerve, especially the contraction of the pupil, which follow extirpation of the superior cervical ganglion gradually become less marked and may disappear or even give place to the opposite condition, especially if the animal is anesthetized or subjected to sensory or emotional stimuli. In other words, extirpation of the upper cervical ganglion causes the symptoms of sympathetic paralysis which may disappear and give place to the signs of sympathetic excitation. Such paradoxical pupillary dilatation may depend on degenerative processes in the post-cellular nerves of the ganglion (Langendorff).

15. The myotic pupil, which follows sympathectomy or gangliectomy, responds to light stimulus, is still further contracted by eserin, and may be dilated by atropin. It is uninfluenced by cocain, which, however, may exercise its influence in widening the contracted palpebral fissure.

16. A considerable excision of the sympathetic must be made in order to prevent a rapid regeneration.

17. Narrowing of the palpebral fissure, ptosis sympathica, and enophthalmos are probably due to relaxation of Müller's muscle, aided, perhaps, by atrophy of the orbital fat. It has not been proved, although it has been asserted, that there is an actual reduction in the size of the globe, that is, a true microphthalmos, under these circumstances.

18. Sympathectomy or gangliectomy may cause increased vascularization of the eyeground, perhaps hemorrhages in the ciliary body and ciliary processes, and alteration in the retinal ganglion cells.

19. Puncture of the restiform body produces just the opposite effects of destruction of the sympathetic (Dupuy).

20. Nicotin paralyzes the activity of ganglionic nerve cells in the sympathetic. Cocain dilates the pupil by stimulating the mydriatic nerve endings in the iris. Atropin dilates the pupil, partly by a paralytic action on the oculomotor endings of the sphincter, and, perhaps, by a stimulant action on the sympathetic nerve fibers, or more likely, by causing a general paralysis of the unstriped pupillary muscle. Instillations of adrenalin, ordinarily inactive in causing dilatation of the pupil, become exceedingly active when the sympathetic is cut or the ganglion removed, and cause under these circumstances marked dilatation of the pupil.

THE INFLUENCE OF RESECTION OF THE CERVICAL SYMPATHETIC GANGLIA IN GLAUCOMA.

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CHICAGO.

This paper does not pretend to be a treatise on the subject mentioned in the title, nor does it assume to give any positive conclusions as to the value of the operation of sympathectomy in glaucoma; for it may be said at the outset that, despite the study of almost all the literature on the subject in its preparation and the collection of published and unpublished data in this country, I feel that positive conclusions are not yet to be reached, and I can only offer this as a contribution that may possibly aid in future work.

I wish at first to express my sincere thanks to the ophthalmologists of the country who so generously responded to the letter asking for data concerning cases of excision of the sympathetic ganglia for glaucoma, and for the latest possible reports of the condition of such cases.

In this way it has been possible to secure records of almost all the cases of glaucoma treated by this means in this country. In several instances the reports seem so favorable that one is tempted to draw general conclusions, while in others the data are so meager or the time that has elapsed since the operation is so short that positive deductions are unwarrantable. Such reports would be more valuable if in every instance careful clinical records had been kept, together with charts of the visual fields. Nothing is more important in the

study of chronic glaucoma than the condition of the peripheral vision, and such record in a number of these cases is lacking.

I desire, first, to present a detailed report of seven cases of sympathectomy for glaucoma in my own practice which are still under observation, two of which are rather recent. I shall then give an abstract of the records of cases of sympathectomy for glaucoma that have been done in this country, as they were furnished to me by the observers in answer to the circular letter sent out this spring. Many of these cases have already been published, but the observers have kindly sent me the latest possible report on the condition:

Case 1.—Chronic inflammatory glaucoma—right eye. Sympathectomy (no benefit). Iridectomy (improvement).

Felix H., aged 40 years. Entered Illinois Eye and Ear Infirmary April 29, 1901. Family history negative, and no previous history of eye trouble until April, 1898, when he lost the sight of the left eye by having it struck with a piece of hot brass. He could see shadows with it until one year before admission. Some three weeks after the injury to the left eye, the right became inflamed, and he states that he was unable to see with it for two or three weeks, and then he recovered vision. In the last two months he has noticed failure of vision, with occasional pain in the right eye. Halos have been noticed around a light. On admission R. E. V.= 20/50 with Cyl.+1.50, 180°, slight improvement. Conjunctiva of right eye injected and there is engorgement of the ciliary vessels. Pupil moderately dilated and vertically oblong. Responds to light. T.+. Optic disc distinctly excavated, but no pulsation of the vessels. L. E. V.=0. Conjunctiva injected; pupil dilated, cataract. T.+1. No perception of light. Fundus not visible. Eserin, grains ii-ℨi, was used three times daily, and the pupil became somewhat smaller and the tension less. For visual fields see Figure 1, which shows marked contraction in all meridians.

May 16, 1901, R. V.=20/70 with Cyl.+1.50, 180°, through stenopaic slit 20/50. Severe pain last night. A. c. shallow. T. +1. Pupil dilated 5 mm. In the afternoon of this day, under chloroform narcosis, Dr. F. C. Schaefer removed the right superior cervical sympathetic ganglion. Contraction of the pupil immediately followed, but tension was not lowered until several hours after the operation. At the time of the operation there was neither pallor nor flushing of the face, nor was there an increase of lachrymal secretion. Ptosis of right side was noticed after recovery of consciousness.

May 17, 1901. Patient comfortable, right pupil contracted. T. lower than before, but still +.

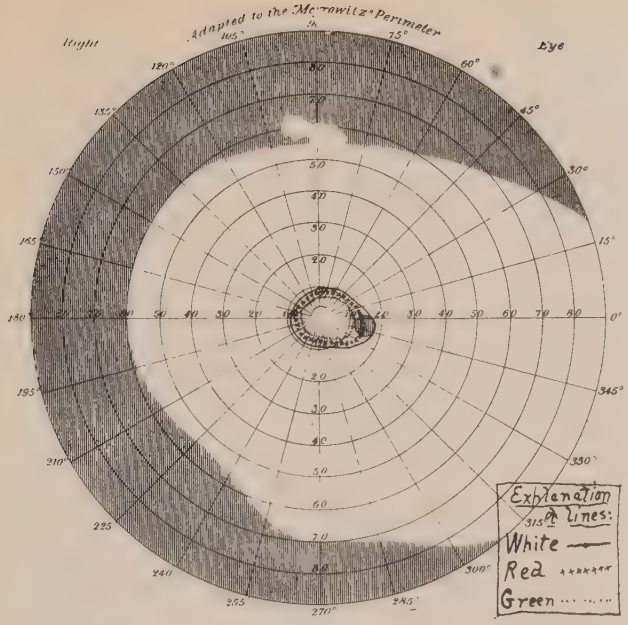

Figure 1, Case 1.—Felix H., aged 40. Before sympathectomy. Chronic inflammatory glaucoma. April 29, 1901. Rt. eye V=20/50. T.+. Good illum. obj. 1 cm. sq.

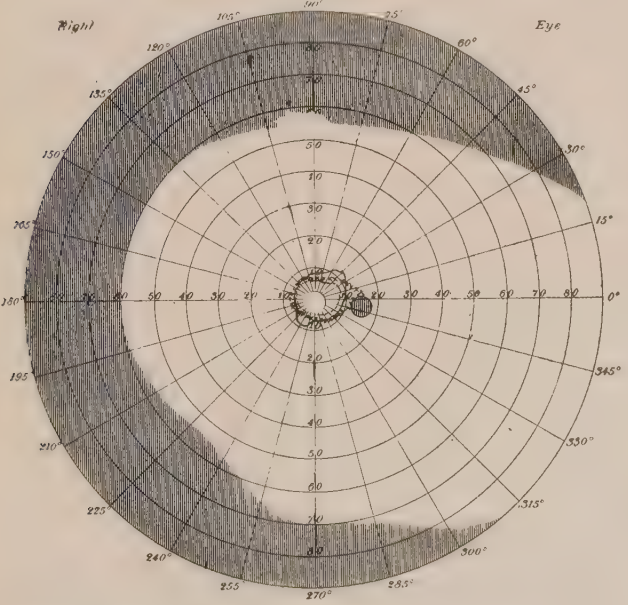

Figure 2, Case 1.—Three weeks after sympathectomy. Chronic inflammatory glaucoma. June 17, 1901. Rt. eye V=20/40. T.+ Good illum. obj. 1 cm. sq.

May 18, 1901. Considerable headache. Pupil contracted. T.+.

May 20, 1901. Considerable pain in wound and head. T. slightly +. R. V. =20/40.

There was some infection of the wound, but by June 7 it had completely healed and patient had no more pain and also no headache. The slight improvement in central vision continued at 20/40 and the tension was only slightly increased. The fields, however, showed no improvement. (Fig. 2.)

June 13, 1901. Vision fell to 20/70, with an increase of tension. This was not controlled by eserin.

June 20, 1901. Tension has been elevated for one week and there has been occasional pain in the eye. Large iridectomy done upward.

June 22, 1901. Very slight reaction from iridectomy.

July 2, 1901. R. V.=20/100. Tension normal. No pain. Central vision began to improve, but occasionally there was slight pain in the eye and slightly increased tension.

From Aug. 2, 1901, to date of his discharge, Aug. 29, 1901, the tension remained normal and the eye was quiet. R. V. with Cyl.+1.00. Ax. 20°=20/30+. Visual fields were unchanged. See Figure 3.

Case 2.—Chronic inflammatory glaucoma. Both eyes. Rt., sympathectomy (marked temporary improvement). Iridectomy.

Edw. L. V., aged 62 years, entered Illinois Eye and Ear Infirmary June 29, 1901. No history of previous eye disease. History of rheumatism. Father became blind at the age of 70 years. Examination of urine shows nothing abnormal. About five years before patient noticed he would occasionally see rings of color around a light, but it was not until six months before admission that he commenced to have pain in his eyes, which he describes as dull, persistent and centering over the left eye. He has noticed a gradual failure of vision, and at different times a complete loss of vision in different fields. There is a history of an acute exacerbation three weeks ago, since which time he has had more trouble. Patient hyperopic. R. E. V. with Sph.+5.00=20/100+1.

Cornea clear, not anesthetic. A. c. shallow. Some circumcorneal injection. Pupil not dilated, responds feebly to light. T.+. Lens slightly cloudy. Disc deeply cupped with glaucoma halo.

L. E. V. with Sph.+5.00 = Fingers at 5 feet in temporal field. Pupil normal in size. T.+. Some opacity of crystalline lens. Disc deeply cupped. For fields of right eye see Figure 4. It was impossible to chart the field of vision of the left eye. Eserin, grains ii-℥i, t. i. d., was used in each eye.

Operation July 12, 1901. Under ether narcosis the right superior cervical sympathetic ganglion was removed by Dr. F.

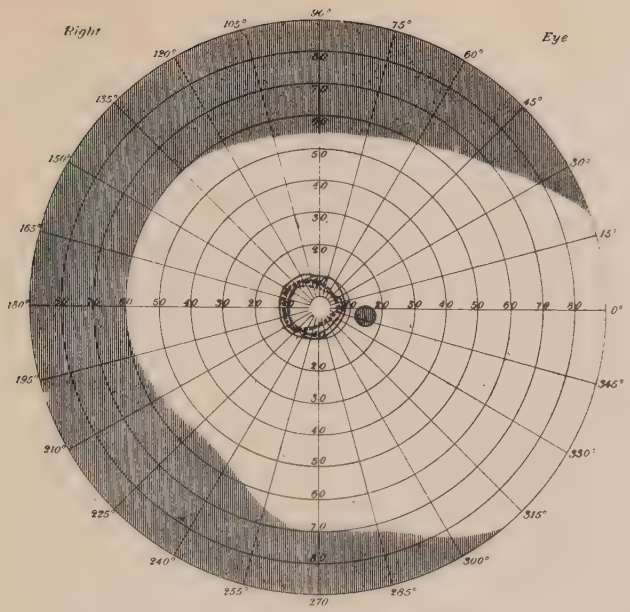

Figure 3, Case 1.—Five weeks after iridectomy. Chronic inflammatory glaucoma. Aug. 29, 1901. Rt. eye V.—20/30+. T. n.

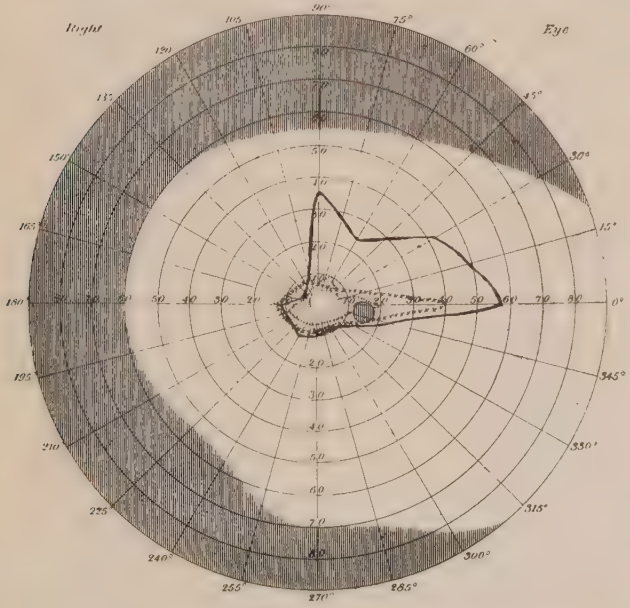

Figure 4, Case 2.—Edw. V., aged 62. Chronic inflammatory glaucoma. June 29, 1901. Rt. eye V=20/100. T.+. Obj. 1 cm. sq.

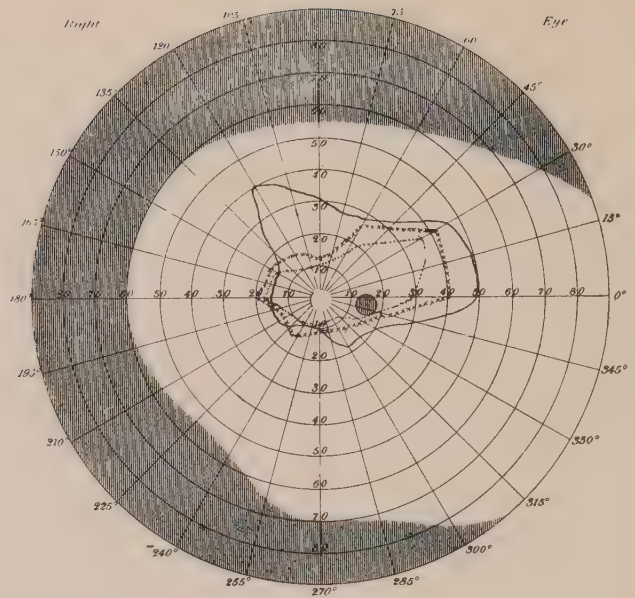

Figure 5, Case 2.—Eighteen days after sympathectomy. Chronic inflammatory glaucoma. July 30, 1901. Rt. eye V=20/40+. T. n. Obj. 1 cm. sq.

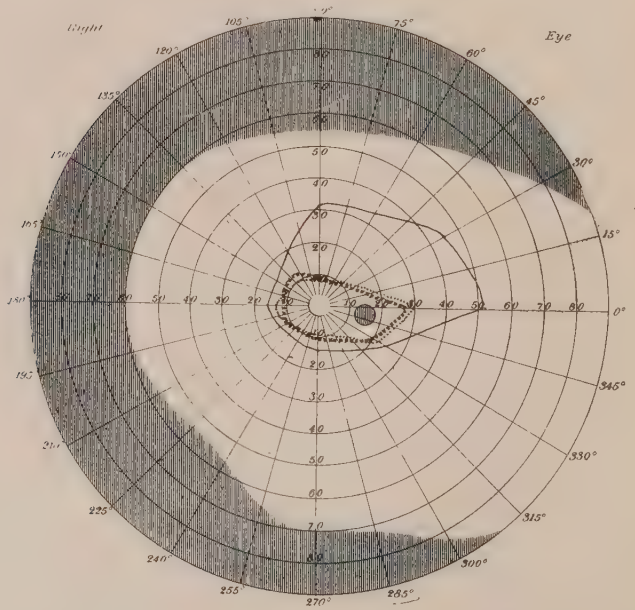

Figure 6, Case 2.—One month after sympathectomy. Chronic inflammatory glaucoma. Aug. 8, 1901. Rt. eye V=20/30. T. n. Obj. 1 cm. sq.

C. Schaefer. The operation was successfully and easily performed and the patient bore it well. Soon after the operation it was noticed that the right pupil was contracted, there was ptosis and the tension was about normal.

July 16, 1901. R. V. with Sph.+5.00=20/50. Pupil small. T.+.

July 17, 1901. R. V. with Sph.+5=20/70. Pupil small. T.+. Wound in the neck healed by first intention and patient experienced no ill effects from it. Vision began to improve, although tension remained slightly increased.

July 30, 1901. R. V. with Sph.+5.00=20/40+. Fields increased (Fig. 5). Tension is also nearer normal.

Aug. 8, 1901. R. V. with Sph.+5.00=20/30. Tension normal. Field (Fig. 6).

Aug. 31, 1901. He left the hospital against my advice. T. n. R. V.=20/30. Field as above.

Oct. 26, 1901. Readmitted to the hospital. R. V. with glass =20/70. L. V. with glass=Fingers 6 in. Tension of right eye decidedly plus. The impairment of central vision is probably due to increasing cloudiness of the central portion of lens. The left lens was much more opaque than when he left the house in August. The visual fields of the right eye had become markedly contracted, as seen in Figure 7. As the tension remained high I did an iridectomy on the right eye Nov. 14, 1901, followed one week later by an iridectomy of the left eye. Although the operation was easily performed and without accident or complication, it had the effect of causing the opacity of the lens to increase more rapidly. The tension returned to normal and patient left the hospital Dec. 6, 1901. R. V.=15/200. L. V.=shadows. He promised to return as soon as the cataract in the right eye made him helpless, but although I have endeavored to find him, I have not seen him since.

Case 3.—Simple glaucoma, both eyes. Left sympathectomy, without benefit. Left iridectomy, with questionable benefit.

Dr. John H., aged 46 years, consulted me Nov. 15, 1901, referred by Dr. A. E. Prince, Springfield, Ill. General health good. At the age of 20 he had granulated eyelids, from which he suffered for two years, recovering completely. No trouble of eyes since that time until January, 1901, when his eyesight began to grow dim, and he would occasionally see halos around a light with the left eye. These attacks of dimness of vision, during which he seemed to be looking through a "fog or haze," came on at intervals of five or six days, and lasted several hours. There was no pain, redness or tenderness of the eyes during these attacks or during the intervals. He noticed that his sight was usually clearer in the morning than in the afternoon. Four weeks before coming to me he consulted Dr. Thompson of Indianapolis, who pronounced his case glau-

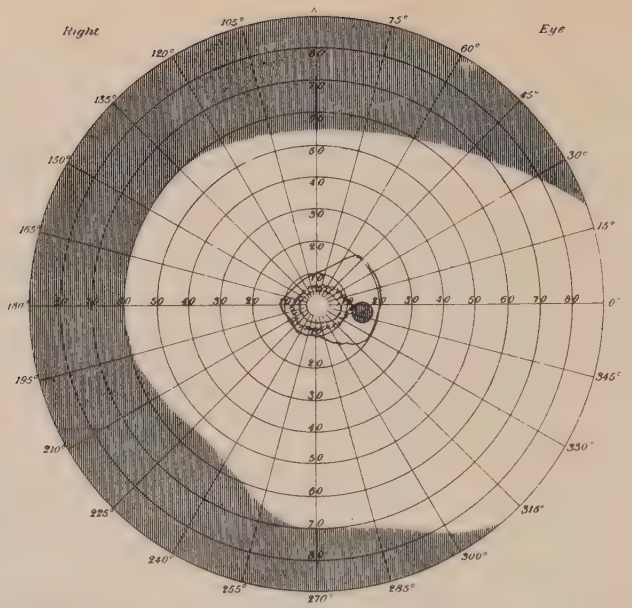

Figure 7, Case 2.—Fourteen weeks after sympathectomy. Chronic inflammatory glaucoma. Oct. 26, 1901. Rt. eye V=20/70. T.+1. Obj. 1 cm. sq.

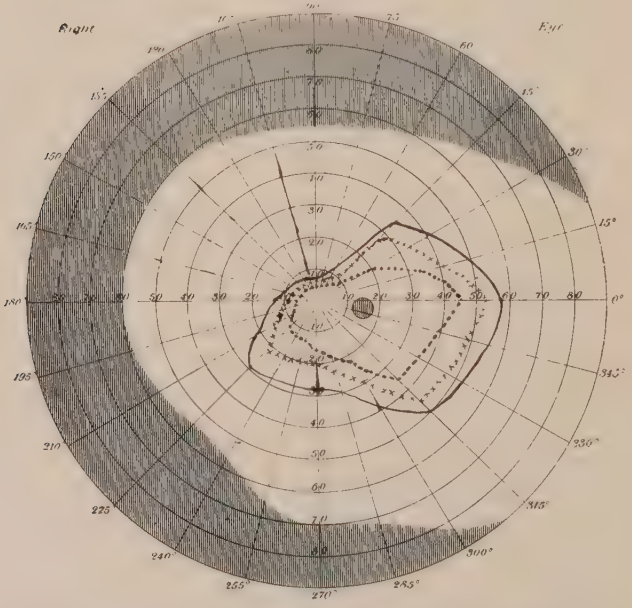

Figure 8, Case 3.—Dr. J. H., aged 46. Simple glaucoma. Nov. 16, 1901. Rt. eye V=20/200. T.+1. Obj. 1 cm. sq.

coma and prescribed eserin, which he was using at the time. Condition at time of first examination, Nov. 15, 1901: R. V. with Sph.+2.00⌒Cyl.—3.50, 180°=20/200. L. V. with Sph. +4.00⌒Cyl.+3.00 75°=20/200. He was wearing such lenses constantly. Both pupils small and somewhat irregular and do not respond to light. Tension of each +1.

On discontinuing the use of the eserin for one day the pupils dilated moderately so that the fundus could be seen clearly. There was a deep glaucomatous excavation in each disc. The fields (Figs. 8 and 9), taken Nov. 16, 1901, showed marked contraction in the nasal region, that of the right noticeably so. The anterior chamber was about of normal depth. After discussing the question of operation with the patient it was decided to do a sympathectomy on the left side. Nov. 20, 1901, the left superior cervical sympathetic ganglion was excised by Dr. Schaefer at the Post-Graduate Hospital under chloroform narcosis. The operation was successfully performed. Immediately after the operation the left pupil, which had been without eserin for two days and was moderately dilated, contracted, and the tension became normal. The patient recovered nicely from the operation, but had some sensitiveness of the left side of the neck and face and inability to raise the left arm and shoulder. He was also quite hoarse, and this symptom persisted.

Dec. 1, 1901. L. V. with Sph.+4.00⌒Cyl.+3.00 75°=20/200. T. n., pupil small, ptosis of left. Fields show no increase. R. V. with Sph.+2.00⌒Cyl.—3.50, 180°=20/200. Pupil small from pilocarpin. T. n., sometimes +.

Dec. 30, 1901. Condition same as on December 1. Color fields slightly enlarged (Fig. 10). He left the city with instructions to continue the miotic and to report at once if his sight began to get worse.

Feb. 12, 1902. Patient returned with the statement that his sight was failing. R. V. with glass=10/200. L. V. with glass=8/200. Pupils moderately contracted. T.+. Fields of left contracted, as shown in Figure 11.

Feb. 14, 1902. Broad iridectomy upward in left eye. The eye made a good recovery from the operation.

Feb. 24, 1902. R. V. with glass=15/200. T. n. L. V. with glass=6/200. T.—. Patient is somewhat hoarse and has imperfect power of the left shoulder. He left Chicago for his home in southern Illinois. He continued the use of pilocarpin, grs. ii-℥i.

A letter from him written April 19, 1903, tells me that he has R. V. with glass=13/200. L. V. with glass=9/200. The left vision, however, seems to be somewhat brighter than the right. He says the fields are limited upward and downward, but fairly good to the temporal side. The tension in each eye is plus, that of the right being a little higher than the left.

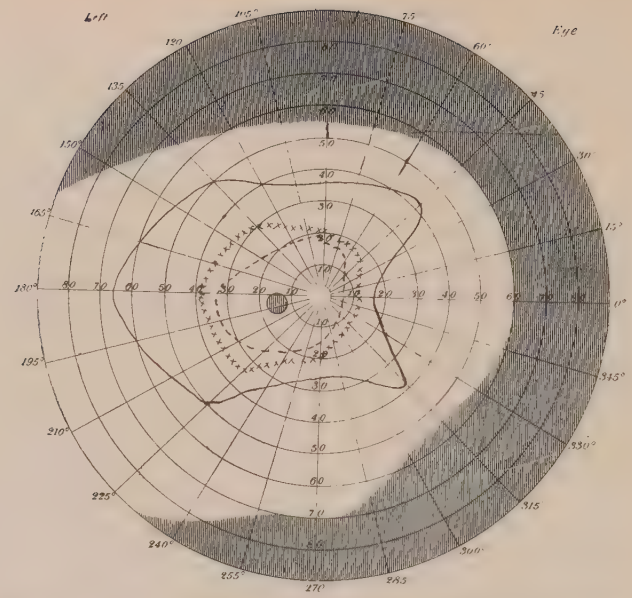

Figure 9, Case 3. Before sympathectomy. Simple glaucoma. Nov. 16, 1901. Left eye V=20/200. T.+1. Obj. 1 cm. sq.

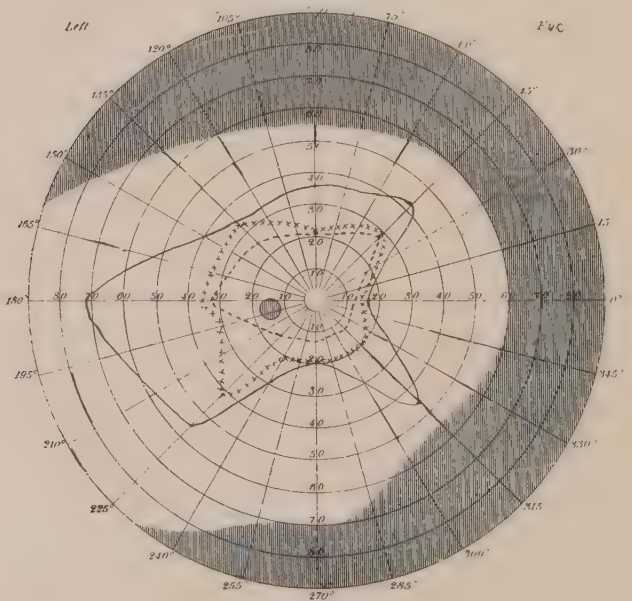

Figure 10, Case 3.—Five weeks after sympathectomy. Simple glaucoma. Dec. 30, 1901. Left eye V=20/200. T. n. Obj. 1 cm. sq.

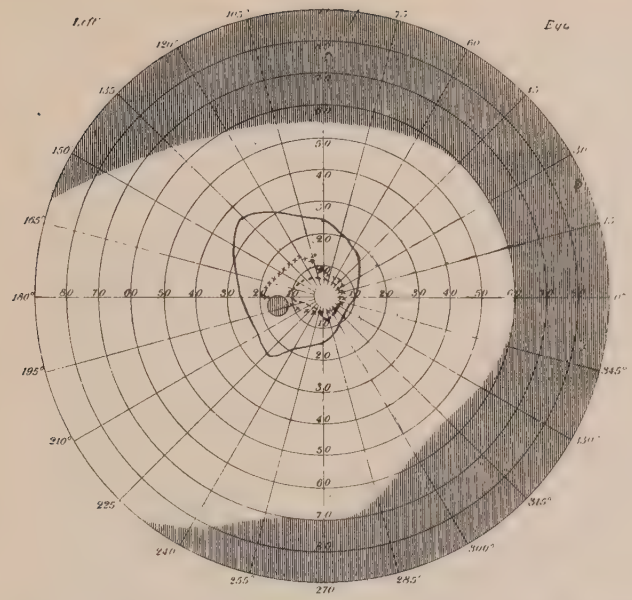

Figure 11, Case 3.—Three months after sympathectomy. Simple glaucoma. Feb. 12, 1902. Left eye V—8/200. T.+. Obj. 1 cm. sq.

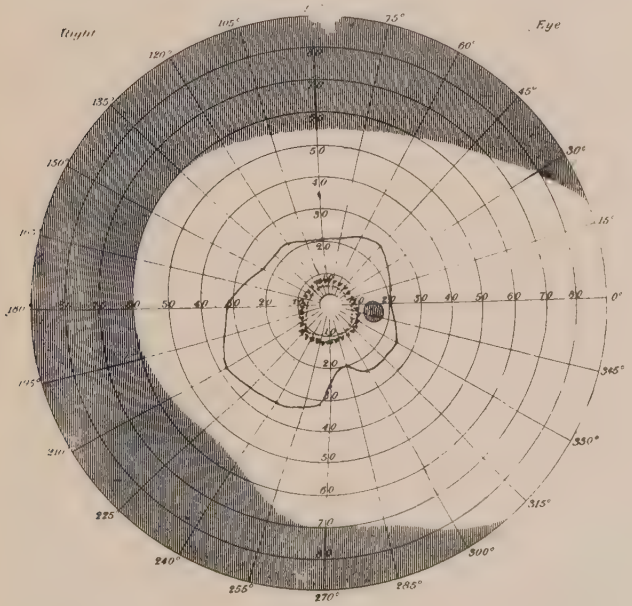

Figure 12, Case 4.—Christian K., aged 74. Simple glaucoma. Oct. 7, 1902. Rt. eye V=20/70. T.+. Obj. 1 cm. sq.

He says he never has the least pain or trouble in any way in the eyes and his condition is such that he "can get around with comparative comfort," and attend to his duties as postmaster, a position he obtained after giving up his practice. His voice is hoarse and weak, and his neck in front of the scar is sensitive.

Case 4.—Right, simple glaucoma. Left, absolute glaucoma. Right, sympathectomy (improvement).

Christian K., aged 74, admitted to Illinois Eye and Ear Infirmary Oct. 3, 1902. One year before, he had severe pain in the left eye, which lasted two weeks, and which was pronounced neuralgia by one physician who saw him, and another said his impaired vision was due to a developing cataract. Halos were noticed around a light and the eye was considerably reddened. The sight was very imperfect after this period of painfulness, but the eye quieted down. Eight months later he had a most severe attack of pain in the left eye, which lasted two or three hours, after which he discovered that the eye was completely blind. This attack was pronounced neuralgia by the physician who saw him after it was over. Soon after this experience he noticed a fogginess of the vision of the right eye, more marked at times than at others. Halos were occasionally seen around lights, but he had very little or no pain in the eye. He is a strong, healthy man with no history of previous disease. Urine normal.

On admission R. V.=20/70. Emmetropia. L. V.=0. Right eye T.+(?). A. c. of normal depth, pupil not dilated, and responds to light and acc. Optic disc not markedly cupped, but of a grayish unhealthy appearance with indistinct margin, such as is seen in incipient glaucoma.

Left eye, T.+3. Marked pericorneal injection. Pupil moderately dilated and shows a greenish reflex. Fundus invisible. Diagnosis: right, simple glaucoma; left, absolute glaucoma. Eserin, grain i-℥i, twice daily for each eye. The first chart of visual fields taken a few days after his admission is seen in Figure 12. This was not taken by myself, and may be somewhat inaccurate, for the next field, Figure 13, taken on Oct. 15, 1902, after several days' use of eserin, shows a considerably increased field; but as the central vision had improved to 20/40 from 20/70, and the tension had become normal after the use of the miotic, the improvement in the fields may probably be ascribed to the treatment. All the other fields were taken carefully by myself.

Oct. 20, 1902. Excision of the right superior cervical sympathetic ganglion was made by Dr. F. C. Schaefer, without any difficulty. Pupil became small immediately after the operation and tension became reduced. Ptosis followed, but there was no pain about the face or neck and no congestion of the conjunctiva or skin. Patient made an excellent recovery

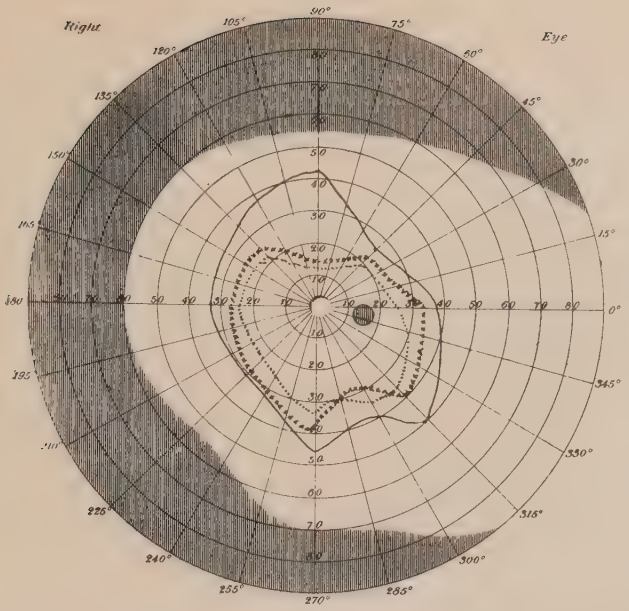

Figure 13. Case 4.—After 1 week of eserin. Simple glaucoma. Oct. 15, 1902. Rt. eye V= 20/40. T. n. Obj. 1 cm. sq.

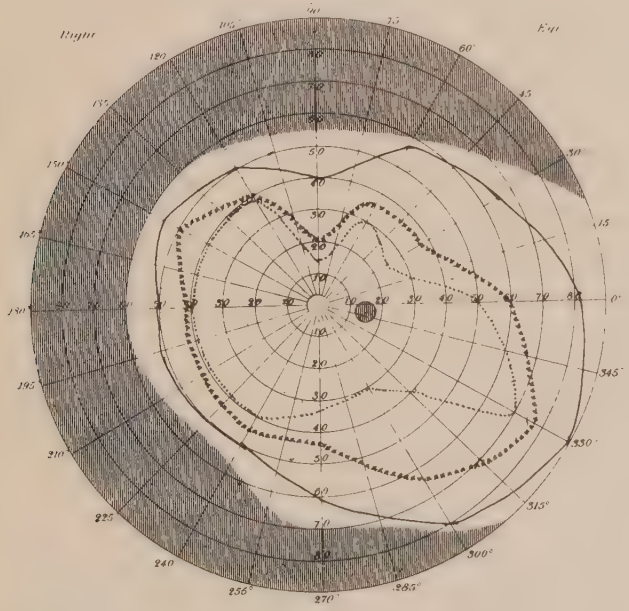

Figure 14. Case 4.—Two weeks after sympathectomy. Simple glaucoma. Nov. 5, 1902. Rt. eye V=20/40. T. n. Obj. 1 cm. sq.

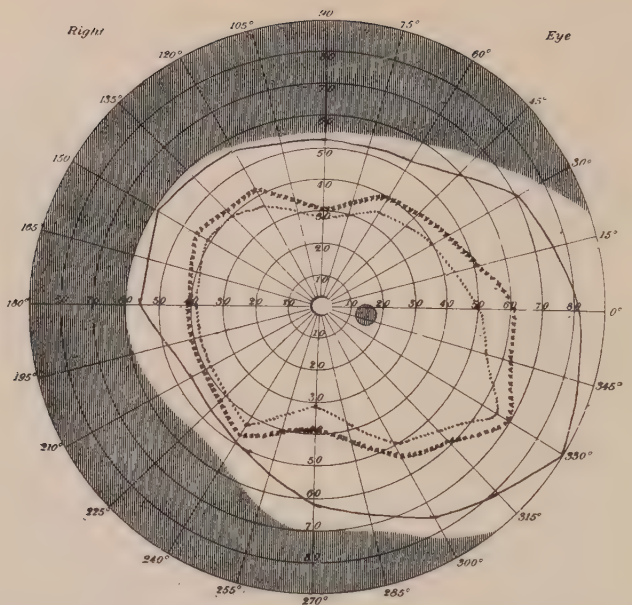

Figure 15, Case 4.—Eight weeks after sympathectomy. Simple glaucoma. Dec. 17, 1902. Rt. eye V=20/40+2. T. n. Obj. 1 cm. sq.

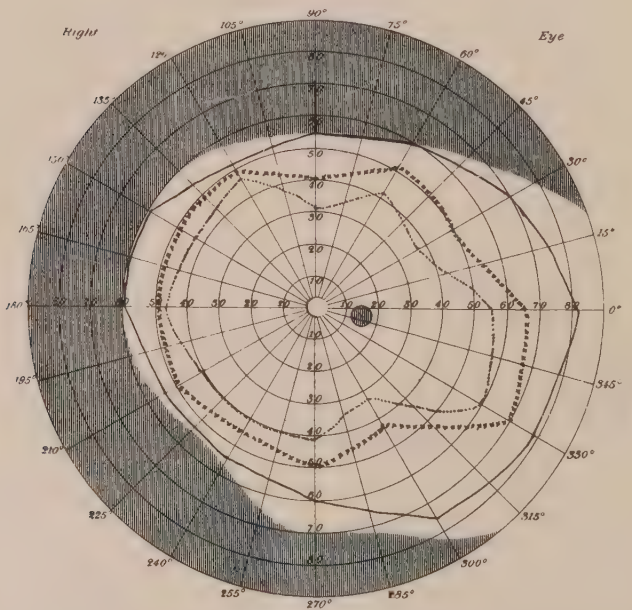

Figure 16, Case 4.—Six months after sympathectomy. Simple glaucoma. April 20, 1903. Rt. eye V=20/40+. T. n. Obj. 1 cm. sq.

from the operation with no unfavorable symptoms. Slight ptosis of the right eye was noticed.

Oct. 28, 1902. Pupil contracted. T. n. R. V.=20/40.

Nov. 5, 1902. Fields show a remarkable improvement. (See Fig. 14.) R. V. 20/40. T. n.

Dec. 17, 1902. Improvement continues. Fields almost normal (Fig. 15). R. V.=20/40+2. Patient still has some pain in right side of face and jaw, as well as the right auricle.

Jan. 14, 1903. Left the hospital to-day. R. V.=20/40+2. T. n. Pupil contracted. Field same as above.

April 18, 1903. Readmitted. In left eye there has been severe inflammation and ulceration of the cornea, which began two or three weeks ago. R. V.=20/40+. Pupil still contracted and T. n. Fields normal (Fig. 16). It will probably be necessary to enucleate the left eye.

Case 5.—Simple glaucoma left eye. Sympathectomy. Disease stationary.

J. S., aged 76 years. First consulted me Nov. 12, 1902, complaining that for weeks previously he had the sensation of a fog being over the left eye. He had also noticed halos around a light at night. This phenomenon of colored rings he had noticed at times for years, but he remembered that at such times there was usually a slight secretion from the lids. He also experienced at times a dull pain in the left eye, and the same but less frequently in the right. He stated that at one time he had severe neuralgic pains extending from the bridge of the nose backward around the left orbit to the ear. General health good, except that he had at times indistinct rheumatic pains and suffered from a bladder disturbance, probably on account of prostatic enlargement. He wears glasses. R. Sph.+1.50 with Cyl.+1.00, Ax. 15°. L. Sph.+1.75 for distance, and R. Sph.+5.00⌒Cyl.+1.00, Ax. 15°. L. Sph.+5.00 for reading prescribed by an ophthalmologist a year or so before. R. V. =20/100 with glass, 20/30+. L. V.=25/70 with glass, 20/30. Right tension normal. Left tension slightly plus, pupil contracted with miotic, anterior chamber of normal depth, optic disc shows glaucomatous excavation, that of the right is normal. The chart of the right fields (Fig. 17) shows slightly contracted color fields. That of the left (Fig. 18) shows a scotoma in the upper nasal quadrant. Pilocarpin, grs. ii-℥i, t. i. d., was ordered.

Dec. 1, 1902. Tension has remained about the same as before under the use of pilocarpin. Pupil remains small and anterior chamber of good depth. L. V. with glass=20/30. Left fields show somewhat more contraction in the upper nasal quadrant. (Fig. 19.)

Dec. 2, 1902. At a consultation with Dr. Hotz it was decided to advise an operation. As the anterior chamber was of normal depth, and the fields have not improved under the con-

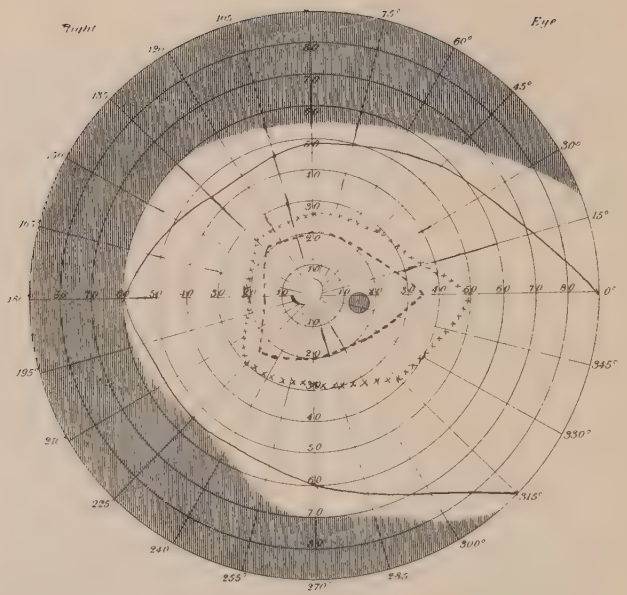

Figure 17. Case 5.—J. S., aged 76. Simple glaucoma. Nov. 12, 1902. Rt. eye V=20/30+. T. n. Obj. 1cm. sq.

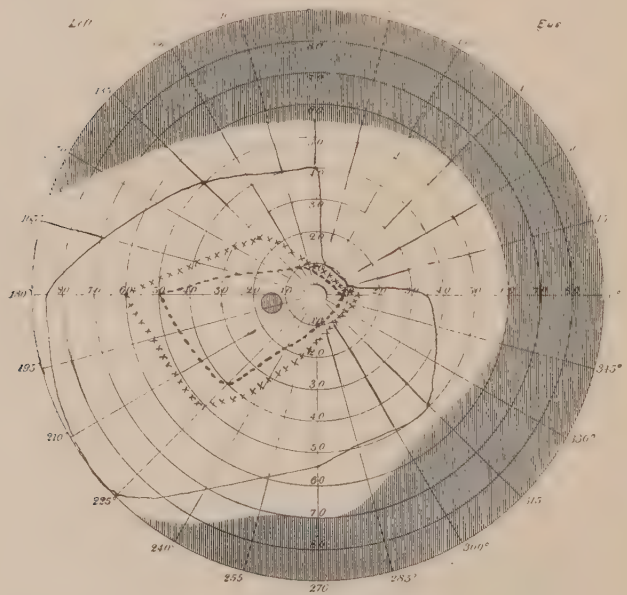

Figure 18. Case 5.—Simple Glaucoma. Nov. 13, 1902. Left eye V=20/30. T.+. Obj. 1 cm. sq.

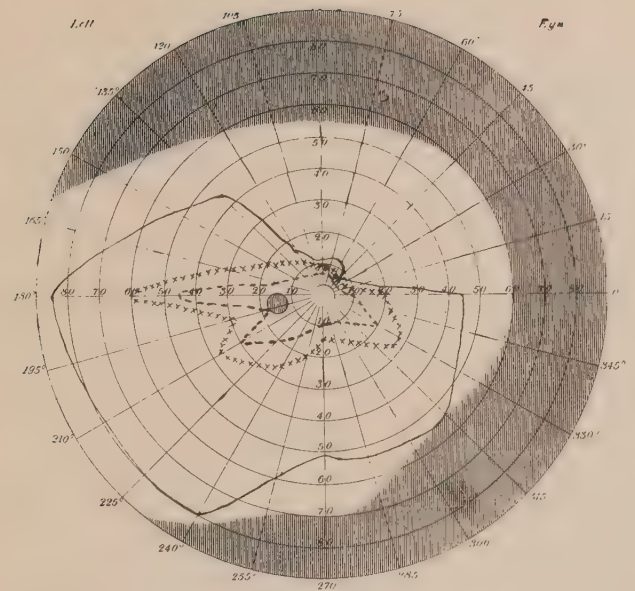

Figure 19, Case 5.—Simple glaucoma. Dec. 1, 1902. Left eye V=20/30. T.+. Obj. 1 cm. sq.

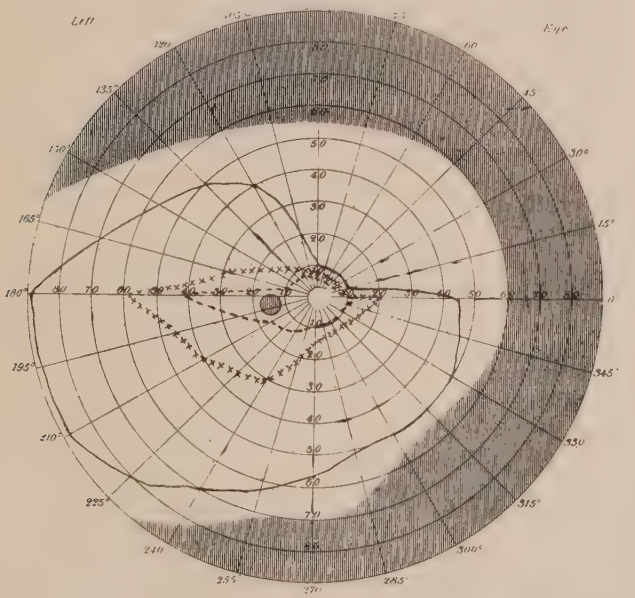

Figure 20, Case 5.—Twelve days after sympathectomy. Simple glaucoma. Dec. 18, 1902. Left eye V=20/20—2. T. n. Good illum. Obj. 1 cm. sq.

tinued use of a miotic, although the pupil was markedly contracted, it was thought that sympathectomy offered as good a chance of checking the glaucoma as iridectomy. The subject was thoroughly discussed with the patient and his family, and it was finally decided to try first the operation on the neck.

Dec. 6, 1902. Under chloroform narcosis the left superior cervical sympathetic ganglion was excised by Dr. Schaefer in the usual manner. The pupil, which for the last few days had recovered from the influence of the miotic, contracted promptly after the removal of the ganglion. There were no accidents or difficulties accompanying the operation and the patient recovered well from the anesthetic. He had complete aphonia, and marked hoarseness continued for more than a week. There was suffusion of the left eye and some congestion of the conjunctiva, mucous membrane of the left side of the nose and skin of left side of the face lasting for a couple of days. Ptosis of the left side was also noted. The patient was also confused mentally and at times had mild hallucinations and did not remember where he was. This rather alarming symptom continued for about one week, and gradually disappeared. There was tenderness about the angle of the jaw and some pain in masticating. Tension remained normal without miotic. Wound healed by first intention.

Dec. 18, 1902. Hoarseness has disappeared. Ptosis. General condition good. L. V. with glass=20/20—2. T. n. Field not markedly changed except that it seemed slightly increased in the upper nasal quadrant for white, and slightly decreased for green in the lower temporal area (Fig. 20).

The patient went to his home in an adjoining state soon after this date, with instructions to use pilocarpin regularly.

Jan. 21, 1903. Reported to me again on this date. Refraction has changed somewhat, for now he sees best with Sph.+ 1.25 Cyl.+0.50, 180°, which gives him L. V.=20/30. Pupil small. Tension slightly plus. Field was taken in a poor light as compared with the others, and shows more contraction, especially for colors, and a notch appears in the upper temporal field (Fig. 21). He still has some pain at corner of left jaw when he eats. Slight ptosis.

Case 6.—Simple glaucoma, left. Absolute glaucoma, right. Sympathectomy, left (improvement).

Margaret T., aged 78, entered the service of Dr. Beard in Illinois Eye and Ear Infirmary Jan. 25, 1903, and was kindly referred to me. Strong, well-preserved woman, who has usually had good health, except that since childhood she has had frequent attacks of sick headache, which continued up to two years ago, when the sight of her right eye began to fail, followed soon after by failing vision of the left. Early in the course of the disease she noticed halos around a light. On admission, R. V.=perception of light in temporal field. T.+.

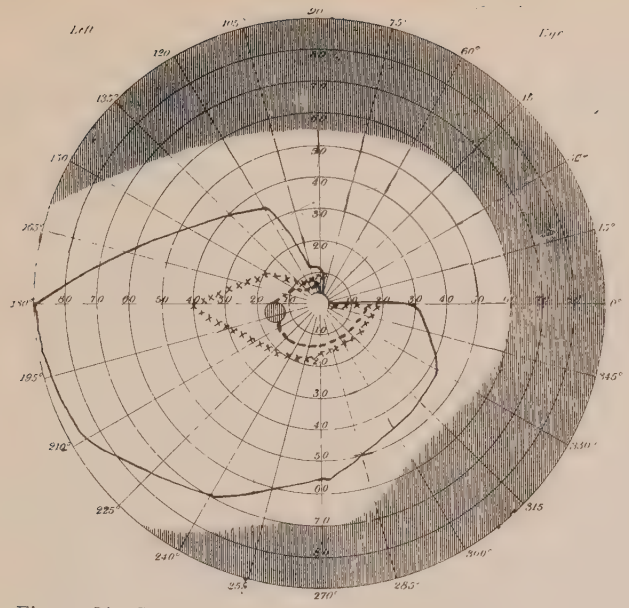

Figure 21, Case 5.—Six weeks after sympathectomy. Simple glaucoma. Jan. 21, 1903. Left eye V=20/30. T.+ (?). Poor illum. Obj. 1 cm. sq.

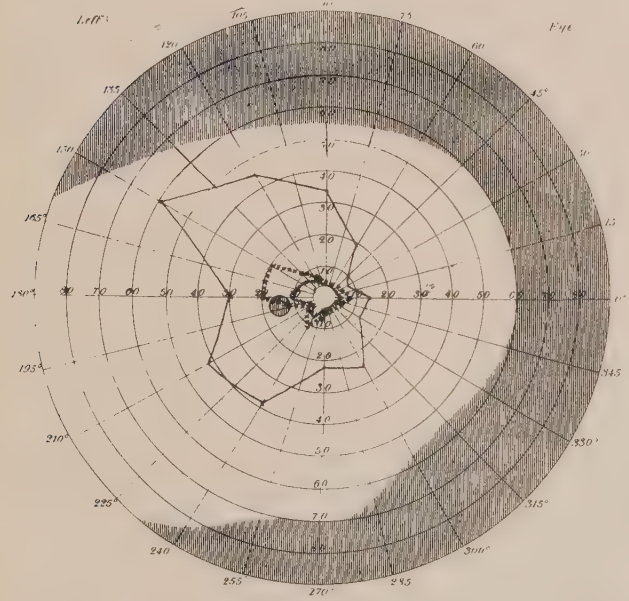

Figure 22, Case 6.—Margaret T., aged 78. Before sympathectomy. Simple glaucoma. Jan. 30, 1903. Left eye V=8/200. T.+. Obj. 1 cm. sq.

A. c. of normal depth, pupil slightly dilated, spicules of opacity in the periphery of the lens. Optic disc sharply cupped, with atrophy and glaucomatous halo. L. V.=8/200 with Sph.+3.50, slight improvement. T.+. A. c. of normal depth, pupil slightly dilated, faint spicules of opacity in periphery of lens; well marked, but rather shallow excavation of optic disc with halo. Retinal veins somewhat engorged. Disc rather pale. No pulsation of arteries or veins. Patient is hyperopic and has been wearing Sph.+3.25 for distance. She has marked arteriosclerosis, the superficial arteries being very hard. Urinalysis shows specific gravity 1024 albumin and no casts. The visual fields of the left eye (Fig. 22) are markedly contracted, especially the color fields, and the nasal side is almost obliterated. Fields of right eye could not be charted. Under eserin and pilocarpin the tension was reduced to nearly normal and the pupils contracted.

Feb. 14, 1903. Left pupil considerably dilated 5 mm. T.+.

Feb. 16, 1903. Excision of left superior cervical sympathetic ganglion by Dr. A. E. Halstead under morphia and chloroform narcosis. The operation was uneventful and immediately after the removal of the ganglion the left pupil contracted.

Feb. 17, 1903. T. n., slight ptosis left, pupil contracted. Has headache and is hoarse.

Feb. 19, 1903. Pupil again somewhat dilated, but not so much as before the operation. It was suspected that two days before the operation some atropin had been put into the eye accidentally by the use of an atropin dropper when the eserin was being instilled and that this accounted for the sudden mydriasis. Immediately after the operation the pupil contracted for 24 hours, then dilated for a few days, and then again contracted and remained so. Headache persists and there is anesthesia of the left auricle.

Feb. 26, 1903. Ptosis of left. Pupil ½ mm. smaller than the right. T. n. L. V.=13/200.

March 10, 1903. L. V.=13/200 with Sph.+3.50=20/200. T. n. Pupil remains smaller than right. Hoarseness and headache have disappeared and sensation has returned to left ear.

March 30, 1903. L. V.=18/200 with Sph.+3.50=20/120. T. n. Right pupil 3½ mm., left pupil 3 mm. Ptosis persists. Fields improved (Fig. 23).

April 15, 1903. Left hospital with instructions to use pilocarpin and to return at once if vision begins to fail.

June 1, 1903. Readmitted to hospital. L. V. with Sph. +3.50=20/200. T. n. Left pupil smaller than right. Fields about the same as in Figure 23.

Case 7.—Simple glaucoma, left; simple absolute glaucoma, right. Left sympathectomy (without benefit). Left iridec-

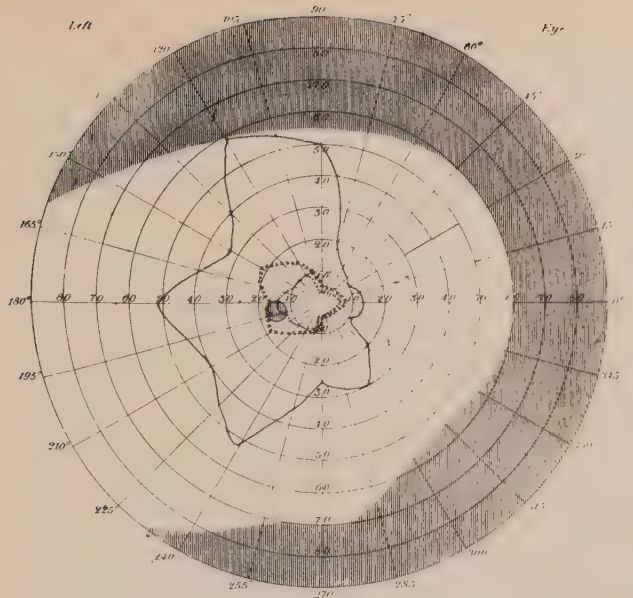

Figure 23. Case 6.—Six weeks after sympathectomy. Simple glaucoma. March 30, 1903. Left eye V=20/200. T. n. Obj. 1 cm. sq.

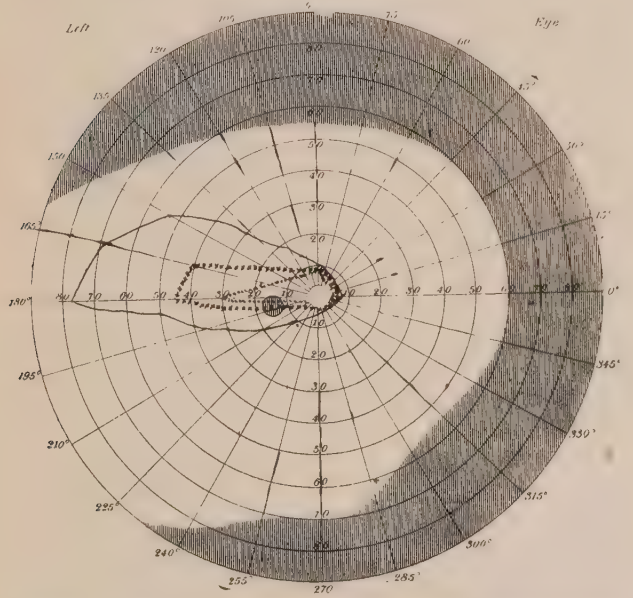

Figure 24. Case 7.—Chas. D., aged 57. Before sympathectomy. Simple glaucoma. Feb. 10, 1903. Left eye V=20/40. T.+ Obj. 1 cm. sq.

tomy, complicated with intraocular hemorrhage. Loss of sight.

Chas. F. D., aged 57, was admitted to the Illinois Eye and Ear Infirmary Feb. 10, 1903, where he was assigned to the service of Dr. Chas. H. Beard, who kindly transferred him to my service. Patient usually had good health and excellent sight until two years before, when he first noticed that the vision of the right eye was foggy at times, and he would see halos around a light. The right vision continued to fail, but he had no pain or inflammation in it. Three months before his admission the same trouble began in his left eye, so that

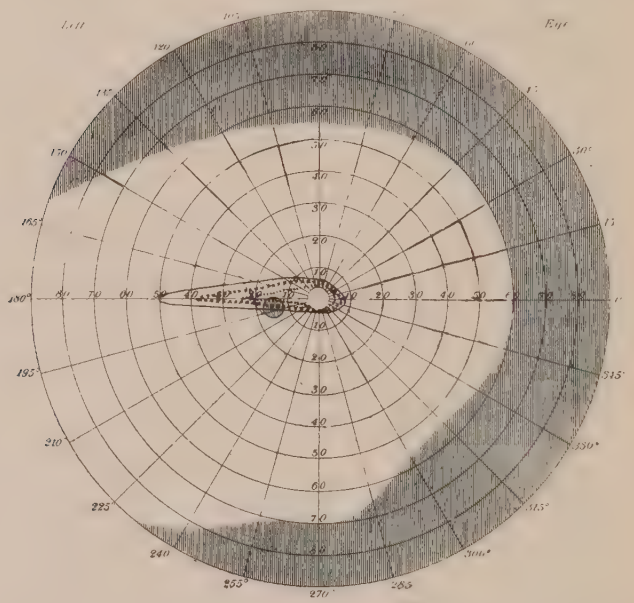

Figure 25, Case 7.—One month after sympathectomy. Simple glaucoma. March 13, 1903. Left eye V=20/40. T.+1. Obj. 1 cm. sq.

he could no longer see well to do the fine work that his occupation, that of bronze sculpture work, required. Three weeks before entrance to the hospital he first noticed halos about a light with the left eye. He states that he has had occasional attacks of temporary blindness in both eyes, lasting a few minutes. Urine normal. Arterial tension rather high. R. V. perception of light. T.+. No fields. Media somewhat hazy. Optic disc deeply cupped. L. V.=20/100 with Sph.+1.50= 20/40, pupil responsive to light and moderately dilated, a. c.

normal in depth. T.+. Glaucomatous excavation of optic disc. Fields markedly contracted, only a small temporal field remaining (Fig. 24).

Feb. 16, 1903. Removal of left superior cervical sympathetic ganglion under morphia-chloroform narcosis by Dr. A. E. Halstead. The operation was somewhat difficult on account of the patient's thick neck. The ganglion was very small, but

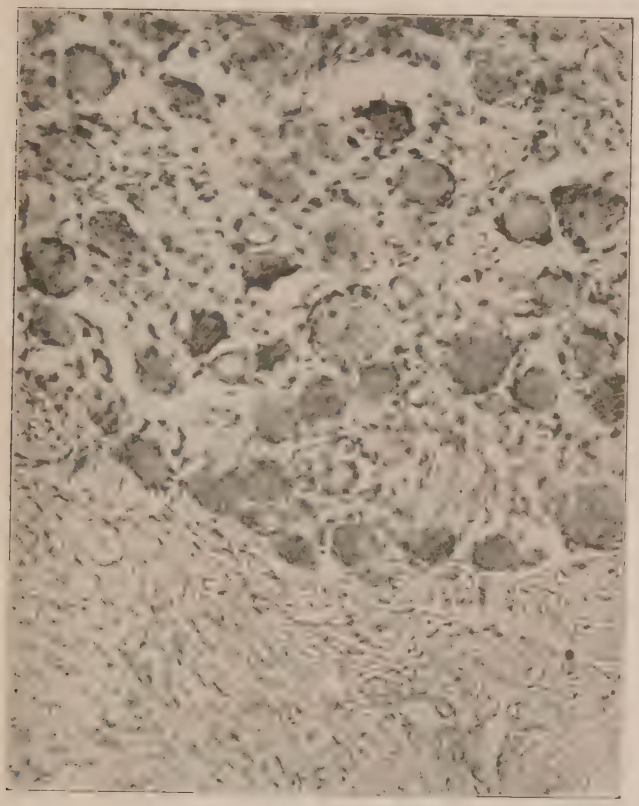

Figure 26.—Section of ganglion from Case 4. Pigmented, irregular cells with excentric nuclei.

was removed with about 3 cm. of the nerve. Spinal accessory nerve was cut and was afterward united with catgut suture.

Feb. 17, 1903. Patient recovered well from the operation. Pupil is contracted, ptosis marked. Partial anesthesia of left side of face and neck. T.+ as before.

Feb. 26, 1903. L. upper lid droops about 2 mm. more than

right. Right pupil 4 mm. L. pupil 2½ mm. L. V. with Sph.+1.50=20/40. T.+. Pain in left side of face and jaw, slight hoarseness and some loss of power in left shoulder. The hyperesthesia of the left side of the face about the jaw and ear was intense, so that he could not bear the slightest touch. Eserin was used regularly.

March 13, 1903. L. V. with Sph.+1.50=20/40. T.+l.

Figure 27.—Section of ganglion from Case 5, showing marked vascularity.

Ptosis and miosis persist. Hyperesthesia of the face gradually getting less. Fields much contracted, being reduced to a narrow slit (Fig. 25).

March 17, 1903. Anterior sclerotomy. Slight reduction of tension.

March 21, 1903. Tension again as high as before. Under cocain and holocain anesthesia an iridectomy was done upward. Immediately after completing the corneal incision the wound gaped widely and after a portion of the iris had been excised vitreous began to present in the wound and the patient complained of intolerable pain. After cutting off the portion of extruding vitreous the lens was forced into the wound and

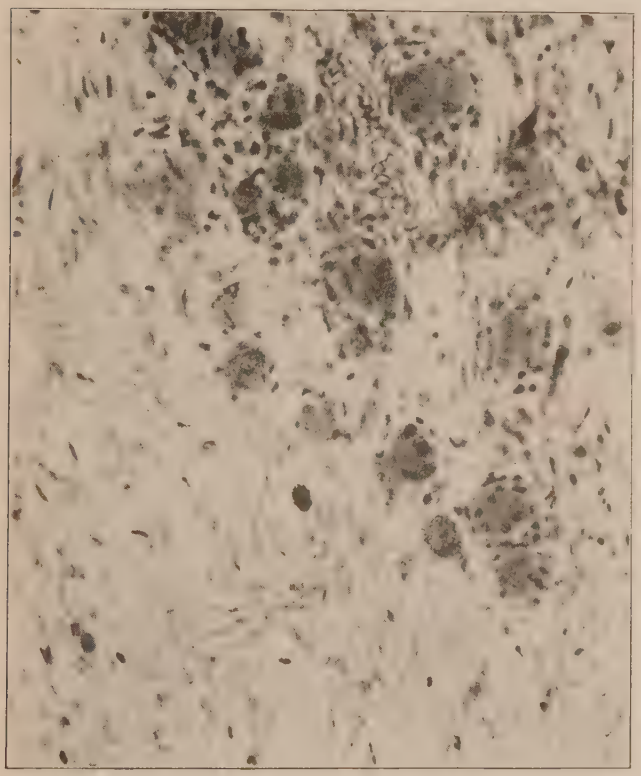

Figure 28.—Section of ganglion from Case 6, showing pigmentation of the cells and apparent increase of connective tissue.

had to be removed. Then followed more vitreous and a copious hemorrhage, the patient all the time experiencing great suffering. The bleeding was finally checked and the eye bandaged. The patient was given an opiate and put to bed, and immediately had a severe chill.

March 22, 1903. Patient was fairly well and not suffering much. In the gaping corneal wound was seen a clot of blood

and a tissue resembling iris or choroid. There was comparatively little reaction after the operation. The wound became smooth by the separation of the protruding mass and the blood in the anterior chamber was absorbed. At the present time, April 20, 1903, the wound has healed. Eye sensitive to touch. T.—2. V.=0. Sensitiveness of the side of the face

Figure 29.—Section from ganglion of Case 7, showing irregularly shaped, deeply pigmented cells.

has disappeared and the patient has completely regained the power of the arm and shoulder.

The excised ganglia in the last four cases were prepared by Dr. E. V. L. Brown, the pathologist of the Illinois Eye and Ear Infirmary, and were examined by

him and also by Dr. Sydney Kuh, professor of diseases of the nervous system at the Post-Graduate Medical School. To these gentlemen I am indebted for the notes on the histologic appearances of the specimens. All the specimens were hardened in 5 per cent. formalin and corrosive acetic solution and stained with toluidin blue and with hematoxylin and eosin.

In all of the specimens there was increased pigmentation of the ganglion cells. In Cases 4 and 5, mast cells were seen. In Cases 4, 5 and 7 it was noted that the cells were not round, but of irregular shapes (Figs. 26, 27, 29).

In one case, No. 6, cells slightly vacuolated were observed. In two cases, Nos. 4 and 5, it was noted that the cells showed excentric nuclei, and in the same cases marked vascularity was present (Figs. 26-27.) Some of these features, especially the pigmentation and the vascularity, are shown in the accompanying photomicrographs. None of the specimens shows conspicuous increase of connective tissue, as has been noted by some other observers, although Figure 28 at the place where the picture was taken apparently shows it. The histologic examination lacks completeness, as, unfortunately, there was not available for control study normal ganglia from individuals of the same age as the patients. As the pigment in the ganglion cells is normally increased in advancing age, it can not be said that these present an abnormality.

REPORT OF 61 ADDITIONAL OPERATIONS OF EXCISION OF SUPERIOR CERVICAL SYMPATHETIC GANGLION FOR GLAUCOMA.

JAMES MOORES BALL. THREE CASES[1] OF GLAUCOMA. FOUR OPERATIONS.

No. 8.—Glaucoma absolutum rt. Rt. sympathectomy. Improvement.

Man, aged 36. R. V.=P.l. L. V.=20/70. Pain in right eye for two months. Chronic irritative glaucoma. Optic disc cupped. T.+3.

Operation.—May 15, 1899. Excision rt. sup. cerv. sympth. ganglion. Tension fell to +1, ptosis. Vision increased to fingers at 3 ft. Report April 4, 1903, pain was relieved for one year. T. +1.

1. N. Y. Med. Jour., 1899.

Nos. 9 and 10.—Simple glaucoma. Both. Bilateral sympathectomy, slight improvement.

Woman, aged 43. R.V.=0. T.+3. L.V.=P.1. T.+3. Duration, two years. No pain. Optic disc cupped. No fields taken.

Operation.—Left sympathectomy, June 15, 1899. Lachrymation. Ocular congestion and contracted pupil of same side followed. Ptosis. Eighth day counted fingers 4 ft. June 30, 15th day, F. 5 ft. in temporal field. T. n.

Operation.—July 16, 1899. Right sympathectomy. Four days later, R.V. hand movements. L.V.=F. 7 ft. R. T. +1. L. T. +1. Report April 4, 1903. Patient became blind in November, 1899, from an acute attack of glaucoma, left.

No. 11.—Hemorrhagic glaucoma. Sympathectomy. Temporary improvement. Report of author April 4, 1903, that he once removed the sup. cervical sympathetic ganglion in a man 26 years old for relief of pain in hemorrhagic glaucoma. Relief of pain was immediate and lasted ten months. One year after operation the man had his eye removed. No further details were given.

MELVILLE BLACK. ONE CASE. SUBACUTE GLAUCOMA.[2]

No. 12.—Sympathectomy. Cure. First reported October, 1901, *Ophth. Rec.* M., aged 35. Colored. Left eye. Duration 2 mos. R.V.=5/5. L.V.=F. 1 ft. after eserin =5/20. Left cornea steamy and no view of fundus obtainable. After eserin pupil was so small that fundus could not be seen. Left T.+2, pupil dilated. Fields normal after eserin.

Operation.—Dec. 24, 1900. Excision of left superior and middle cervical sympathetic ganglia, followed by immediate return to normal vision, normal tension, contracted pupil 1½ mm. and normal fields. Ptosis, congestion of conjunctiva, increased lacrymation were noted.

Report April 7, 1903. L.V.=5/6 with Sph.+1.00. R. pupil 4 mm. L. pupil 3 mm. T. n. Fields normal. No symptoms of return of glaucoma nor any other symptoms of inconvenience. Ptosis scarcely noticeable and the conjunctival injection had disappeared. Slightly myopic before operation. Now hyperopic 1 D. No complications or accidents attending operation.

CALLAN. ONE CASE. BUPHTHALMUS. SECONDARY GLAUCOMA.

No. 13.—Sympathectomy. No improvement. M., aged 25 years. Highly myopic. R.V. with Sph.—20 Cyl.—1.00, 105°=20/200. L.V. with Sph.—22.00=20/200. History of gradually failing sight. Nystagmus. Tension plus 1 in each. Marked excavation of optic discs.

Operation.—May 26, 1902. Excision of rt. sup. cerv. sym-

2. Ophthalmic Record, October, 1901.

pathetic ganglion. After op. R. E. T.—1. L. E. T.+1. Both pupils contracted. No ptosis, congestion of face or other phenomena. No accidents or complications.

Report March 27, 1903 (by letter). "Tension at present time +1. The only improvement is that the operated eye is not so prominent and possibly the nystagmus not so marked. Tension, pupil and vision remain the same as before the operation. The cosmetic effect is an improvement."

D. H. COOVER. ONE CASE.[3]

No. 14.—Simple glaucoma. Both. Rt. sympathectomy; temporary improvement.

M., aged 65 years. Failing vision for one year. R. V.=P.l in temporal field. T. +3. Optic disc cupped. L. V.=20/200. T.+2. Disc cupped. Fields contracted. Miotics useless.

Operation.—March 31, 1900. Excision of right sup. cerv. sympath. ganglion. A few days later tension somewhat lower. R. V.=5 ft. Four months later R. V. again reduced to P.l. T. +3. L. V. had fallen from 20/200 to 5/200.

COLEMAN W. CUTLER. ONE CASE. RIGHT CHRONIC IRRITATIVE GLAUCOMA. LEFT, ABSOLUTE GLAUCOMA. RIGHT, SYMPATHECTOMY, GREAT IMPROVEMENT. PREVIOUS IRIDECTOMY.[4]

No. 15.—M., aged 56. Duration of disease 8 years. History of attacks of pain, cloudy vision, halos and failing sight. Sclerotomy in 1897. Iridectomy in right in 1898. June 2, 1901, R. E. F. 3 ft. T. +½ to 1. L. E. V. 0. T. +2. After eserin R. V.=20/200+. Pain in both eyes. Fields contracted.

Operation.—June 10, 1901. Excision of rt. sup. cerv. sympath. ganglion. One day after T.—½. V.=20/30. Slight ptosis, some dysphagia, pain in right side of head and face and impaired phonation. Improvement continued. Fields increased. May, 1902, one year after, R. V.=20/30. Fields increased. No signs of nerve lesions except some paresthesia of side of face and neck and occasional sharp pain in temporomaxillary articulation.

Last report, March 27, 1903, by letter. Cutler has not seen patient since Aug. 25, 1902, but thinks if results had not been favorable he would have called.

W. A. FISHER. ONE CASE. CHRONIC GLAUCOMA. RIGHT SYMPATHECTOMY. NO IMPROVEMENT.

No. 16.—F., aged 62. Both eyes affected for two years. R. V.=12/200. T. n. Pupil somewhat dilated. Excavation of optic disc. Fields contracted.

Operation.—June 8, 1899. Excision of rt. sup. cerv. sympath. ganglion. No accidents or complications. Operation negative

3. Phila. Med. Jour., March 16, 1900.
4. Annals of Surgery, Phila., September, 1902.

as to effect on lid, conjunctiva, tears, respiratory passages and skin of face. Negative as to effect on vision. Last report April 4, 1900, ten months after operation, R. V.=4/200. L. V. =0. No effect on pupil or vision. Fields unchanged.

HENRY GRADLE. ONE CASE. CHRONIC GLAUCOMA. PREVIOUS IRIDECTOMY. SYMPATHECTOMY. (STATIONARY).

No. 17.—F., aged 33 years. Both eyes affected, left for a period of three years. Both optic discs cupped. R. V.= 20/40+. Fields normal on temporal side, contracted above 10°, down 10°, inward 15°. Pupil moderately dilated on account of large coloboma. T. +. Two iridectomies had been done, one 30 months, the other 15 months before, both having apparently delayed the course of the disease, but not stopping it entirely. L. V.=0. No report of this eye.

Operation.—March 13, 1900. Excision of sup. cerv. sympth. ganglion of rt. side. No accidents or complications. After operation T.— and is normal after two and a half years. Pupil distinctly contracted for two or three months, and two and a half years after operation it is as it was before. Central vision unchanged, 20/40+. Doubtful enlargement of fields at first, but practically stationary during two and a half years. After operation there was ptosis, slight congestion of conjunctiva and skin of face. These all receded in a few months.

E. GRUENING. TWO CASES. ONE CHRONIC GLAUCOMA (BOTH). ONE OPTIC ATROPHY (BOTH). CASE 1, PREVIOUS IRIDECTOMY. SYMPATHECTOMY. SLIGHT IMPROVEMENT.[5]

No. 18.—M., aged 60 years. Both eyes affected with chronic glaucoma for three years. R. V.=F. in upper temporal quadrant at 2 ft. T. +1. Field in upper temporal quadrant. Disc deeply cupped. Coloboma from previous iridectomy. L. V.=0. T.+1. Disc deeply cupped.

Operation.—In 1901. Removal of rt. sup. cerv. sympath. ganglion. There was no change in pupil. T. n. and remained so for one year after operation. Patient retained same central and peripheral vision at time of last report, one year after operation. Ptosis. Paralysis of recurrent laryngeal causing dysphonia that lasted nine months and then disappeared.

No. 19.—Left sympathectomy. No improvement.

M., aged 35. Atrophy of both optic discs of two years' standing. Both optic discs white. R. V.=0. L. V.=20/30. Fields of left contracted to 10° in every direction. Tension normal in each.

Operation.—1902. Removal of left sup. cerv. sympath. ganglion. As a result of the operation there was some sinking of the eyeball, and also paralysis of left recurrent laryngeal

5. Ophth. Sec. N. Y. Academy of Medicine, November, 1901.

nerve. Dysphonia lasted about six months, although the paralysis of the recurrent laryngeal persisted. Tension remained normal. Left vision was completely lost two months after the operation.

A. B. HALE. ONE CASE. THREATENED GLAUCOMA, LEFT. ABSOLUTE GLAUCOMA, RIGHT. LEFT SYMPATHECTOMY.

No. 20.—F., aged 48. Total loss of vision of right eye after two iridectomies had been done. R. V.=0. T.+. Deep excavation of optic disc. L. V. with Sph.+1.00=6/5. T.+(?) Optic disc normal. Pupil normal. Fields contracted and wavering.

Operation.—Dec. 15, 1902. Excision of left sup. cerv. sympath. ganglion. After operation L. V. with Sph.+1.00=6/5. T.—. Pupil small. No effect on lid, conjunctiva, lachrymation, skin. Loss of sensation on lower half of ear. Last report March 1, 1903. Condition as above. Fields normal. T. n. Operation was done to ward off an impending attack of glaucoma. This operation was preferred because the right eye had been lost after two iridectomies.

J. G. HUIZINGA. TWO CASES. 1, CHRONIC SIMPLE GLAUCOMA, BOTH EYES. DOUBLE SYMPATHECTOMY. NO IMPROVEMENT. 2, CHRONIC INFLAMMATORY GLAUCOMA, BOTH EYES. LEFT SYMPATHECTOMY. NO IMPROVEMENT.

NOS. 21 AND 22.—M., aged 57. Both eyes affected for 17 years. R. V.=P.1. T.+1. Fields greatly contracted. L. V. 6/20. T. n. Field for white contracted, being almost obliterated on the nasal side; 65° temporal side, 10° above, 40° below. Color fields about 10°.

Operation.—Oct. 14, 1898. Excision of both sup. cerv. sympath, ganglia. Immediate effects, conjunctiva injected, slight increase of lachrymation. Inspiration difficult from slight edema of glottis. Patient quite hoarse for several weeks, but fully recovered. No material change in vision of either eye. T. n. and remaining so one year afterward. Pupils that were about 4 mm. before operation contracted slightly afterward, and then returned to the usual size. One year afterward there was no change.

No. 23.—M., aged 36. Chronic inflammatory glaucoma of both eyes of several years' duration, with recurring attacks. R. V.=F. 3 ft. T.+3. Pupil widely dilated because of atropin used by patient's physician. Fields could not be taken. Optic discs could not be clearly seen. L. V.=F. 3 ft. T. 3. Pupil same as right. Fields could not be taken. Disc could not be seen.

Operation.—January, 1902. Excision of left sup. cerv. ganglion and at the same time iridectomy on each eye. Result: Vision became worse and worse, until there was com-

plete blindness. Considerable lachrymation for several weeks after operation. One year after, R. V. T.+1. L. T.+2. No accidents or complications from the sympathectomy.

ARNOLD KNAPP. ONE CASE. CHRONIC GLAUCOMA WITH ATROPHY, BOTH EYES. BILATERAL SYMPATHECTOMY AFTER RIGHT IRIDECTOMY.

NOS. 24 AND 25.—M., aged 20. No history as to duration. R. V.=16/200 after successful iridectomy. Optic disc deeply cupped and atrophic. L. V.=12/200. T.+2. Disc cupped and atrophic. Fields contracted to 10° of center.

Operation.—June 10, 1902. Excision of both sup. cerv. sympath. ganglia. Slight drooping of both upper lids followed. Hoarseness that lasted several weeks. V. improved to 20/200 each. R. T. n. L. T.+(?). Fields did not change.

Last report March 18, 1903, ten months after operation. R. V.=20/200. T. n. L. V.=12/200. T.+. Fields same as before.

HARRY LA MOTTE. FOUR CASES. ACUTE INFLAM. GLAUCOMA (BOTH). IRIDECTOMY, RIGHT, RECOVERY. SYMPATHECTOMY, LEFT, RECOVERY.[6]

No. 26.—M., aged 27. Duration of disease three months. Acute attacks of glaucoma relieved by eserin. Cupping of discs. R. V.=F. 6 ft. Iridectomy. Vision improved in six weeks to 20/50. L. V.=P.l. T.+1. Field not taken.

Operation.—March 25, 1901. Excision of left sup. serv. sympath. ganglion and connections. Ptosis, increased lachrymation and injection of conjunctiva followed. Pupil before operation was dilated. After operation it contracted. T. became normal.

Last report July 10, 1902. R. V.=20/40. T. n. Field somewhat contracted. Pupil contracted. L. V.=20/20. T. n. Field normal. Pupil normal.

CHRONIC INFLAM. GLAUCOMA (BOTH). DOUBLE SYMPATHECTOMY. RECOVERY.

NOS. 27 AND 28.—F., aged 38. Duration of two and a half years, during which time she had occasional attacks of severe pain, increased tension, impaired vision. In the intervals between attacks vision approached nearly to normal. R. V.=20/30. L. V.=20/40. Slight cupping of optic discs. Visual fields were not taken.

Operation.—May 1, 1901. Excision of left sup. cerv. sympath. ganglion. Pupil contracted afterward and has remained so. Slight ptosis occurred, but no other manifestation except an-

6. Ophthalmic Record, Chicago, October, 1902; Denver Medical Times, March, 1903.

esthesia of side of face and neck, which disappeared after several months. L. V. before operation 20/200. Vision returned to 20/20. T. n.

Operation.—July 9, 1901. Excision of rt. sup. cerv. sympath. ganglion. For about one week before R. V. had been much reduced and there was considerable pain. R. V.=P.l. T.+1. Optic disc cupped. After operation vision soon returned to normal. T. n. Slight ptosis, increased lachrymation, pupil contracted, pain and discomfort disappeared.

Last report Sept. 1, 1902. R. V.=20/20. T. n. Some contraction of fields. L. V.=20/20. T. n. Contraction of fields to 40°.

SIMPLE GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. IMPROVEMENT.

No. 29.—M., aged 43. Duration of disease six months. Had been treated by some quack doctor who had been giving atropin for iritis. L. V.=20/20. Eye normal. R. V.=F. 3 ft. T.+2. Pupil dilated. Visual fields could not be taken.

Operation.—Jan. 24, 1902. Excision of rt. sup. cerv. sympath. ganglion. No unfavorable signs. No ptosis, conjunctiva injected, lachrymation increased. T. remained +2, pupil contracted. Central vision improved.

Last report March 23, 1903, fourteen months after. R. V. =20/70. T.+1. Pupil contracted. Fields concentrically contracted. Degree not given.

SIMPLE GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. DEATH FROM SEPSIS.

No. 30.—M., aged 40, large, healthy soldier. History of impairment of vision of right eye for one year. R. V.=20/30. T.+1. Pupil dilated, concentric contraction of fields, slight excavation of right disc. L. V.=20/20. T. n. Pupil normal, slight contraction of fields.

Operation.—Feb. 17, 1903. Excision of rt. sup. cerv. sympath. ganglion. Patient took ether badly and chloroform was substituted. Just before the nerve was excised he vomited suddenly and expulsively and some of the vomit fell into the wound. This was cleansed with the utmost care, but in spite of all precaution infection extended to the deep structures of the neck, and he died of septic pneumonia on the fifteenth day after the operation. After operation T.+1. Pupil contracted. Slight aphonia, increased lachrymation and injection of conjunctiva. Fields were not taken.

JOSEPH MULLEN. ONE CASE. CHRONIC INFLAM. GLAUCOMA (BOTH). PREVIOUS IRIDECTOMY. RT. SYMPATHECTOMY. TEMPORARY IMPROVEMENT.[7]

No. 31.—F., aged 48. History of bilateral iridectomy 23 years previously for acute glaucoma. Gradual decrease in

7. Amer. Med., June, 1901.

vision since that time with occasional acute pains in eyes and head. Severe attack at the time she was first seen by the operator. R. V.=F. 5 ft. T.+2. L. V.=5/200. T.+2. Both optic discs cupped. Right field irregularly contracted to 20° above, 30° temporal, 20° nasal, 15° below. Left field concentrically contracted to about 30°.

Operation.—March 18, 1900. Excision of right sup. cerv. sympath. ganglion. Increased lachrymation. Congestion of conjunctiva and face. Coloboma prevented accurate statement as to pupils. Tension in both eyes normal. Pain was relieved. Fields in both eyes were increased by as much as 10 to 20 degrees all around, the improvement being more marked in the right. Central vision improved. Degree not stated. Three months after operation improvement was lost and increased tension and pain returned.

Nine months later R. V.=15/20. L. V.=20/200. Charts showed decrease of fields nearly to same degree as before operation, with left field very irregular. Last report April 8, 1903. R. V.=20/100. Field as before operation. L. V. =20/70. Field larger than it was Dec. 18, 1900.

W. B. MARPLE. ONE CASE. CHRONIC GLAUCOMA. SYMPATHECTOMY. NO IMPROVEMENT.[8]

No. 32.—Patient who had ribbon-shaped keratitis. V.= 10-15/200. T.+1. Pupil partly dilated.

Operation.—August, 1902. Excision of sup. cerv. sympath. ganglion. After operation T. became normal and pupil diminished in size. Vision unchanged. Patient has been under observation six months.

H. R. PRICE. TWO CASES. SIMPLE CHRONIC GLAUCOMA (BOTH) WITH HEMORRHAGIC RETINITIS AND CHRONIC NEPHRITIS. RIGHT SYMPATHECTOMY. IMPROVEMENT.

No. 33.—M., aged 70. Duration of disease one year. R. V.=P.1. Improved under eserin to 20/200. Pupil dilated. Tension variable from T. n. to T.+3. Fields contracted, especially on nasal side. Numerous hemorrhages in the macular region. Deep excavation of disc. L. V.=20/100. T. n. Pupil normal. Hemorrhages as in the right, typical glaucoma cupping. Before operation R. V. =P.1.

Operation.—May 26, 1902. Excision of right sup. cerv. sympath. ganglion. Pupil contracted, slight hyperemia of conjunctiva and skin of face same side, increased lachrymation slight, and slight ptosis. Seven days after operation R. V. =20/200 with Sph.—1D.=20/100. Field considerably enlarged.

Last report Oct. 3, 1902. Five months after operation

8. N. Y. Medical Record, May 10, 1902.

R. V.=20/100. T. n., pupil contracted. Patient not seen later. Result considered favorable in view of the hemorrhagic condition.

SIMPLE GLAUCOMA. RIGHT SYMPATHECTOMY. HISTORY INCOMPLETE. PREVIOUS IRIDECTOMY MARCH, 1902.

No. 34.—M., aged 55. Duration of disease one year. Had iridectomy done March, 1902. V. B.=20/40, declining to 20/70 with rapid loss of field. Persistent plus tension. Deep glaucoma cupping.

Operation.—Aug. 1, 1902. Excision of right sup. cerv. sympath. ganglion. Tension became minus and ptosis, hyperemia of conjunctiva and face were noticed, as well as slightly increased lachrymation. No other phenomena and no accidents. Patient left hospital 15 days after operation and subsequent history was not obtained.

R. C. REESE. ONE CASE. CHRONIC SIMPLE GLAUCOMA (BOTH). IRIDECTOMY FIVE YEARS BEFORE. RIGHT SYMPATHECTOMY. IMPROVEMENT.

No. 35.—F., aged 58. Duration of disease six years. R. V.=F. 10 ft., not improved with lens. T.+. Pupil shows coloboma. Fields contracted considerably at nasal side. Deep glaucoma cupping of disc. L. V.=0. Pupil and disc as in rt. Double iridectomy had been done five years before, and ever since that time she had used eserin occasionally to keep the tension down.

Operation.—May 28, 1902. Excision of rt. sup. cerv. sympath. ganglion. T.—. No increase of central vision. Slight ptosis and neuralgic pains in the left side of face and neck that lasted for two months.

Last report April 20, 1903, nearly one year after operation. R. V.=F. 10 ft. Fields unchanged. T.—. Does not have to use a miotic.

E. C. RENAUD. SIX CASES (FIVE BILATERAL). CHRONIC IRRITATIVE GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. IMPROVEMENT.[9]

No. 36.—F., aged 48. Duration ten months. R. V.=20/200. T.+3. Pupil dilated and immovable. Media hazy, disc cupped. Fields not taken. L. V.=20/20. T. n. Pupil and fundus normal. Attacks of pain in right eye.

Operation.—Nov. 29, 1899. Excision of rt. sup. cerv. sympath. ganglion. Ptosis of rt. lasted 18 days. Hyperemia of conjunctiva and lachrymation lasted three days. No accidents or complications. R. V. improved to 20/50 and pupil contracted. T. n., later became slightly plus. Pain disappeared within 24 hours.

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9. St. Louis Med. Review, Feb. 1, 1902.

Last report April, 1903. R. V.=20/50. L. V.=20/20. No ptosis. Good condition continues.

CHRONIC SIMPLE GLAUCOMA, BOTH. BILATERAL SYMPATHECTOMY. SLIGHT IMPROVEMENT.

NOS. 37 AND 38.—M., aged 52. Double simple glaucoma. Duration 18 months. R. V. quantitative. L. V.=Large objects at 6 ft. In both eyes T.+2. Pupils dilated, discs markedly cupped. Fields not taken.

Operation.—March 11, 1901. Bilateral excision of sup. cerv. ganglia. Ptosis lasting two weeks. Hyperemia of conjunctiva and some lachrymation for several days. Pupils contracted. T.+1. Vision improved to 6/100 in each.

Last report two years after operation shows that improvement has been retained, although tension is still plus.

CHRONIC SIMPLE GLAUCOMA, LEFT. BILATERAL SYMPATHECTOMY. SLIGHT IMPROVEMENT.

NOS. 39 AND 40.—F., aged 40. Simple glaucoma of left eye of 7 months' duration. R. V.=20/20. T. n. Normal in every way. L. V.=F. 3 ft. T.+3. Pupil dilated and fixed. Disc markedly cupped. Fields not taken.

Operation.—Sept. 9, 1901. Bilateral excision of sup. cerv. sympath. ganglia. Bilateral ptosis for 16 days. Hyperemia of conjunctiva and increased lachrymation for 3 days. Hysterical manifestations. T. n., pupils contracted and L. V.=F. 14 ft. No fields.

Last report April, 1903. Same condition.

CHRONIC IRRITATIVE GLAUCOMA, RIGHT. BILATERAL SYMPATHECTOMY. IMPROVEMENT.

NOS. 41 AND 42.—M., aged 39. Duration of disease in right eye 15 months. Attacks of pain at times. R. V.=P.l. T.+2. Pupil dilated, media hazy, disc sharply cupped. L. V.=20/20. T. n. Media and fundus normal. Eye normal in every way. No fields were taken.

Operation.—Feb. 12, 1902. Bilateral excision of sup. cerv. sympath. ganglia. Bilateral ptosis for 2 weeks. Some injection of conjunctiva and increased lachrymation for several days. Pain relieved. R. V.=F. 12 ft. T. n., pupil contracted.

April, 1903. Last report. Same improved condition.

ACUTE GLAUCOMA, RIGHT. BILATERAL SYMPATHECTOMY. IMPROVEMENT.

NOS. 43 AND 44.—M., aged 57. History of acute glaucoma in right eye for 3 weeks. Severe pain. R. V.=20/100. T.+3. Pupil dilated and fixed. Very slight cupping of disc. L. V. =20/20. Eye in every way normal. No fields taken.

Operation.—June 22, 1902. Bilateral excision of sup. cerv.

sympath. ganglia. Pain in eye disappeared. Ptosis, bilateral, for 13 days. Conjunctival hyperemia and lachrymation. Pupil contracted. R. V.=20/40.

In April, 1903, at time of last report, no return of the trouble.

CHRONIC IRRITATIVE GLAUCOMA, RIGHT. BILATERAL SYMPATHECTOMY. SLIGHT IMPROVEMENT.

Nos. 45 and 46.—M., aged 46. Duration 11 months. History of attacks of pain in right eye. R. V.=20/200. T.+2. Pupil dilated. Disc cupped. L. V.=20/20. Eye normal in every way. No fields taken.

Operation.—Nov. 16, 1902. Bilateral excision of sup. cerv. sympath. ganglia. Ptosis for 12 days, pronounced hyperemia of conjunctiva and moderate increase of lachrymation. Pupils contracted and tension in rt. eye reduced. R. V.=20/100. L. V.=20/20.

Favorable result continues at time of last report, April, 1903.

No recurrence in any of these cases up to date of report, April, 1903. In the irritative cases the pain was relieved in every instance. No difference was noted in the anterior chamber in any case. In the last four cases the ganglion was torn from its attachment with a strong forceps instead of being cut.

G. E. DE SCHWEINITZ. ONE CASE. CHRONIC CONGESTIVE GLAUCOMA, BOTH. BILATERAL SYMPATHECTOMY. UNCERTAIN RESULTS.

Nos. 47 and 48.—M., aged 23. Duration 7 months. R. V. =shadows on temporal side. T.+2. Pupil dilated 5 to 6 mm. Light field on temporal side only. L. V.=shadows imperfectly. T.+2. Pupil dilated 8 mm. Fields contracted so that there was only light perception on temporal side. Green, atrophic, completely cupped discs on each side with typical halo.

Operation.—Dec. 14, 1901. Excision of rt. sup. cerv. sympath. ganglion and a considerable piece of the nerve. Slight ptosis followed and congestion of conjunctiva. T. slightly diminished. Pupil contracted 3 mm., but this lasted only 3 days. R. V.=uncertain counting of fingers in temporal field.

Operation.—Jan. 31, 1902. Excision of left ganglion. No improvement in vision. No change in tension, pupil or field. After first operation decided dysphagia lasting 48 hours. Patient remained free from congestive attacks of glaucoma for two months, then they returned.

JOHN R. SHANNON. ONE CASE. CHRONIC SIMPLE GLAUCOMA, BOTH. LEFT SYMPATHECTOMY. NO IMPROVEMENT.

No. 49.—F., aged 32. Disease existed for 10 years in both eyes. R. V.=15/200. T.—(?). Pupil large, irregular,

a. c. deep. No peripheral vision except in lower temporal quadrant. L. V.=hand movements centrally, F. 3 ft. excentrically. T.+1. Coloboma from iridectomy upwards. Both discs slightly cupped..

Operation.—June 18, 1902. Excision of left sup. cerv. sympath. ganglion. No change in pupil and tension remained increased as before. Slight ptosis.

Fields remained the same April 14, 1903.

J. H. SHORTER. ONE CASE. SECONDARY GLAUCOMA AFTER SYMPATHETIC INFLAMMATION. LEFT SYMPATHECTOMY. SLIGHT IMPROVEMENT.[10]

No. 50.—M., aged 20. Lost right eye from trauma. Glaucoma in left eye for six years following sympathetic ophthalmia. L. V.=F. 3 ft. T.+2. Pupil fixed from posterior synechiæ. Disc not visible on account of central cataract. Large defect on nasal side of field.

Operation.—1901. Excision of left sup. cerv. sympath. ganglion. After operation profuse lachrymation and mucous discharge from left nostril. Conjunctiva and skin of face were injected. Left ptosis. L. V.=F. 6 ft. T. n. one month after operation.

Final examination showed less contraction of visual fields. Anesthesia of left auricle. Transitory hoarseness.

ELMER G. STARR. ONE CASE. SIMPLE GLAUCOMA, BOTH. POSTERIOR SCLEROTOMY. BILATERAL SYMPATHECTOMY. MARKED IMPROVEMENT.

Nos. 51 AND 52.—F., aged 63. Duration one year. Disease had been held in check for nine months with eserin, until by mistake patient used atropin, which caused reduction of vision to F. 4 ft. and increase of tension to +3. Sclerotomy of right eye increased vision to F. 18 ft. Marked cupping of both discs with some atrophy. Immediately before sympathectomy R. V.=F. 18 ft. T.+2. Pupil moderately dilated. L. V.=F. 4 ft. T. n. Pupil moderately dilated. Fields of both eyes typically contracted.

Operation.—Oct. 16, 1902. Bilateral excision of sup. cerv. sympath. ganglia. Result on lid, conjunctiva, etc., *nil.* R. V. =20/50. T.+1. Pupil normal. L. V.=20/50. T. n. Pupil normal.

Last report April 15, 1903, states that above condition persists, but that visual fields have decreased somewhat. For two or three weeks after operation inability to raise the arms. This disappeared. Painful sensation at times in the neck.

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10. Medical News, April 6, 1901.

GEO. F. SUKER. FOUR CASES. FIVE OPERATIONS. SIMPLE CHRONIC GLAUCOMA, BOTH. ABSOLUTE GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. NO IMPROVEMENT.[11]

No. 53.—M., aged 70. Duration about two years. R. V. =0. T.+3. Pupil dilated, a. c. shallow. Fields could not be taken. L. V.=20/200. T. n. Nasal field contracted. Optic discs in both cupped. Iridectomy on left eye in 1898.

Operation.—August, 1899. Excision rt. sup. cerv. sympath. ganglion. Hyperemia of conjunctiva, flushing of side of face and increased lachrymation. No other accidents. Pupil contracted and remained so for three years. No change in fields, tension or vision.

Last observation June, 1902.

SIMPLE CHRONIC GLAUCOMA, BOTH. BILATERAL SYMPATHECTOMY. NO IMPROVEMENT.

No. 54 AND 55.—M., aged 65. Duration between one and two years. R. V.=F. 8 ft. T.+2. Pupil dilated and a. c. rather deep. Pupil concentrically contracted. Glaucoma cupping of disc. L. V.=F. 10 ft. T.+. Pupil and fields as above. Disc not distinctly seen on account of cataractous lens.

Operation.—November, 1899. Bilateral excision of sup. cerv. sympath. ganglion. Hyperemia of conjunctiva followed. Pupils contracted and central vision improved slightly. Fields enlarged somewhat and then contracted to less than before the operation.

Last observation April, 1903. Sees enough to get about.

CHRONIC INFLAM. GLAUCOMA, LEFT. LEFT SYMPATHECTOMY. SLIGHT IMPROVEMENT.

No. 56.—F., aged 67. Disease of two or three years' duration in left eye. R. V.=20/40. T. n. Pupil normal. Fields normal. L. V.=20/100. T.+2. Pupil dilated. Disc shows considerable cupping. Fields contracted on nasal side.

Operation.—September, 1899. Excision of left sup. cerv. sympath. ganglion. Slight ptosis. Increased lachrymation. T. n. Pupil contracted. Fields enlarged considerably. L. V. =20/100.

Last observation April, 1902. Fields slightly enlarged as compared with those before operation. L. V.=20/100. Patient died in 1902.

ABSOLUTE GLAUCOMA, RIGHT. CHRONIC INFLAM. GLAUCOMA, LEFT. PREVIOUS IRIDECTOMY ON LEFT. RIGHT SYMPATHECTOMY. NO IMPROVEMENT.

No. 57.—M., aged 58. History of painful attacks of glaucoma for over one year in both eyes. R. V.=0. T.+3. Pupil

11. THE JOURNAL A. M. A., 1901.

dilated, a. c. shallow. No fields. L. V.=20/80. T. n. Fields normal. Iridectomy had been done sometime before.

Operation.—January, 1900. Excision of rt. sup. cerv. sympath. ganglion. No effect on lid, tension, etc. Pupil contracted. T.+1. No change in central vision or fields.

In two of these four cases there was dysphagia lasting several days.

DAVID WEBSTER. ONE CASE. RIGHT, SIMPLE GLAUCOMA. LEFT, ABSOLUTE GLAUCOMA. RIGHT SYMPATHECTOMY, TEMPORARY IMPROVEMENT. DISEASE STATIONARY.

No. 58.—M., aged 49. Disease for one year in left eye and a few months in the right. R. V.=20/50. T.+. Pupil slightly dilated and sluggish. Field up 40°, down 50°, nasal 50°, temporal 85°. White disc with shallow excavation. L. V. =0. T.+3. Pupil widely dilated, deep glaucoma cupping.

Operation.—Feb. 5, 1902. Excision of rt. sup. cerv. sympath. ganglion. Ptosis followed. Numbness of right side of tongue and hoarseness. T.—. Contracted pupil. R. V.=20/30. Fields improved.

Last report Jan. 22, 1903, one year later. R. V.=20/50. Fields about the same as before the operation. T. n. Miosis, slight ptosis.

JOHN E. WEEKS. FIVE CASES. SEVEN OPERATIONS. SIMPLE CHRONIC GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY, TEMPORARY IMPROVEMENT. ACUTE ATTACK. IRIDECTOMY.[12]

No. 59.—F., aged 56. Duration of disease two years. R. V. =F. 1 ft. T.+2. Pupil dilated, a. c. shallow. Cupping of optic disc. Field for white small, color field abolished. L. V. =20/20. T.+1. Fields not much contracted.

Operation.—March 11, 1902. Excision of rt. sup. cerv. sympath. ganglion. Vision began to steadily improve and she could see colors. Fields increased markedly. Tension remained plus. April 20, 1902, R. V.=20/70. T.+1. June 8, 1902, attack of acute glaucoma in right. V.=P.1. June 20, 1902. Iridectomy of right eye. July 18, 1902, R. V.=F. 7 ft. L. V.=20/20.

SIMPLE GLAUCOMA (ABSOLUTE), RIGHT. SUBACUTE GLAUCOMA, LEFT. LEFT SYMPATHECTOMY, IMPROVEMENT. RIGHT. SYMPATHECTOMY.

Nos. 60 and 61.—M., aged 70. History of 6 months' duration. R. V.=P.1. T.+2. Nerve white and deeply cupped. L. V.=20/40. T.+2. Fields contracted.

Operation.—April 1, 1902. Excision of left sup. cerv. sympath. ganglion. T.—. No untoward symptom.

Operation April 15, 1902, on right side. No untoward re-

12. Trans. Amer. Ophth. Soc., 1902.

sults. July 5, 1902, R. V.=P.1. No change in fields. L. V. =20/20. Fields markedly improved.

SIMPLE CHRONIC GLAUCOMA, LEFT. ABSOLUTE GLAUCOMA, RIGHT. LEFT SYMPATHECTOMY, IMPROVEMENT.

No. 62.—R. V.=0. T.+3. L. V.=20/70. T.+. Duration of disease seven years, during which time he had used eserin. Fields greatly contracted.

Operation.—April 15, 1902. Excision of left sup. cerv. sympath. ganglion. T. n. Pupil small. Suffusion of eye, lachrymation increased. Ten days later L. V.=20/30+.

July 10, 1902, severe pain in left side of head. L. E. T.+. L. V.=20/20. Fields increased. No later report.

SIMPLE GLAUCOMA, BOTH. BILATERAL SYMPATHECTOMY, TEMPORARY IMPROVEMENT. LATER IRIDECTOMY NECESSARY.

Nos. 63 and 64.—M., aged 30. History of failing vision and increased tension in both eyes for three years. R. V.= 20/40+. T.+1.5. Pupil dilated, optic disc cupped, fields contracted.

Operation.—April 29, 1902. Excision of rt. sup. cerv. sympath. ganglion. Pupil contracted. T. n. Acute attack of glaucoma was excited in left eye. L. V.=1/200.

Operation.—May 6, 1902. Excision of left ganglion. Pupil contracted. T.+1. Improvement in vision. T. of right eye remained normal. T. of left remained high and iridectomy was done. July 12, 1902, R. V.=20/20. L. V.=9/200.

Last report March 1, 1903. Iridectomy was done on right eye because of periodic increase of tension and diminution of vision and visual fields. April 11, 1903, R. V.=20/40. T. n. L. V.=F. 17 ft.

SIMPLE CHRONIC GLAUCOMA, BOTH. LEFT IRIDECTOMY, FOLLOWED LATER BY LEFT SYMPATHECTOMY. IMPROVEMENT.

No. 65.—M., aged 40. Duration of disease unknown. R. V.=0. Absolute glaucoma. T.+3. Deep cupping of disc. L. V.=F. 5 ft. T.+. Pupil shows coloboma after iridectomy. Cupping of optic disc.

Operation.—Dec. 2, 1902. Excision of left sup. cerv. sympath. ganglion. Ptosis, suffusion of conjunctiva, increased lachrymation and nasal mucus and free perspiration on side of face opposite to side of operation occurred. Improvement in tension and vision occurred, and at time of last report, three months after operation, T. n., L. V.=20/200.

The ganglion was small, not much larger than trunk of the nerve. It was very pale in color.

MEYER WIENER. TWO CASES. CHRONIC INFLAM. GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. NO IMPROVEMENT.

No. 66.—F., aged 50. R. V.=F. 12 ft. T.+2. Dilated

pupil. Cupped disc. L. V.=0. Phthisis bulbi. Field of right contracted.

Operation.—Winter of 1900. Excision of rt. sup. cerv. sympath. ganglion. No change in vision or tension and patient was lost sight of in four weeks after operation.

CHRONIC SIMPLE GLAUCOMA, RIGHT. RIGHT SYMPATHECTOMY. NO IMPROVEMENT EXCEPT IN PUPIL.

No. 67.—F., aged 45. Duration of disease in right eye 4 years. T.+1. Pupil dilated. Field slightly contracted on inner side. R. V.=6/200. L. V.=6/6. T. n. Eye normal.

Operation.—1900. Excision of rt. sup. cerv. sympath. ganglion. No change in tension or pupil. Vision remained the same. Patient disappeared three weeks after the operation and no further report was made.

H. W. WOODRUFF. ONE CASE. SIMPLE GLAUCOMA, LEFT. LEFT SYMPATHECTOMY WITH TEMPORARY IMPROVEMENT. LATER IRIDECTOMY.[13]

No. 68.—M., aged 29. Failure of right eye for 7 years after an injury. Duration in the left eye three years. R. V.=0. Absolute glaucoma. T.+. Deep cupping of disc. L. V.= 20/40. T.+. Pupil dilated. Fields contracted, cupping of optic disc.

Operation.—April 29, 1901. Excision of left sup. cerv. sympath. ganglion. Six days later ptosis. T. n., contracted pupil, improved vision. White fields that were contracted to 10° increased to 30° up, 30° nasal, 15° below and 50° temporal with irregular outline. Later central vision=20/20. Six months later he had return of all symptoms and failing central vision. He refused iridectomy, but later consented to it, and on Feb. 10, 1902, iridectomy of the left eye was done. Central vision improved to 20/30.

Last report March 10, 1903, L. V.=20/70. T. n. Field greatly contracted. Above 5°, temporal 2°, below 5°, nasal 10°.

We have here records of 68 operations done on 54 cases, i. e., 14 were bilateral. Of these operations, 38 were for simple glaucoma; 16 for chronic inflammatory glaucoma; 4 for subacute glaucoma; 3 for acute glaucoma; 4 for absolute glaucoma; 2 for hemorrhagic glaucoma; 1 for buphthalmus.

Of these five operations were preventive, one by Hale (20), four by Renaud (40, 42, 44, 46). No glaucoma up to time of reports. One death occurred (30). Of the 38 operations for simple glaucoma, 14 gave no improvement whatsoever. Five were temporarily improved

13. Chicago Med. Recorder, July, 1901.

for periods ranging from fifteen days to eight months, but had recurrent attacks that necessitated iridectomy or caused loss of the eye. Fifteen were improved as long as they were under observation, for periods of from two months to two years. Of these three were stationary (5, 17, 58); one died (30); six remained unimproved after iridectomy, but improved after sympathectomy (17, 18, 24, 34, 35, 65).

Concerning the 15 that were improved, No. 9 showed slight improvement; No. 18 improvement as to tension; previous iridectomy had been done; observation, one year; No. 24, improvement as to central vision and tension; No. 29, marked improvement; observation, fourteen months; No. 34, previous iridectomy had been done; improvement after sympathectomy, but patient was only under observation for fifteen days; No. 35, previous iridectomy, after the sympathectomy the tension remained minus; Nos. 37 and 38, slight improvement as to vision, but tension is still plus; time of observation, two years; No. 40, improvement as to tension, slight improvement as to vision; time of observation, twenty months; Nos. 51 and 52, marked improvement in tension and vision; posterior sclerotomy had been done without effect; time of observation, six months; Nos. 62 and 65, previous iridectomy; marked improvement intension and vision; time of observation, four months; Nos. 4 and 6 showed marked improvement, and have been under observation for nine months and four months, respectively.

Of the 16 operations for chronic inflammatory, 6 showed no improvement; 3 showed improvement for periods from two to three months (2, 31, 50); 4 were improved as long as they were under observation; 1 (45) five months, 1 (15) eighteen months, 1 (41) one year, 1 (36) three years.

Of these 1 (15) had not been benefited by iridectomy, but greatly improved by sympathectomy; eighteen months under observation; 3 (20, 42, 46) were preventive, and disease had not appeared at three months, eight months and one year after operation.

Of the four that showed improvement, No. 15 is the most interesting, because an iridectomy failed to check the disease, but sympathectomy produced marked results in central and peripheral vision. Time of observation, eighteen months.

In No. 36, improvement in central vision continued after three years, tension slightly plus; in No. 41, improvement continues after one year; in No. 45, vision and tension were improved and pain was relieved; time of observation, five months.

No. 20 is interesting in that the operation was done for threatened glaucoma.

In Nos. 42 and 46 it is not stated whether the bilateral operation was done to influence more profoundly the diseased eye or to prevent the occurrence of the disease in the perfectly sound eye. The same may be said concerning Cases 39 and 44, in which one eye was normal in every respect.

Of the 4 operations for subacute glaucoma, 1 (12) cured at the end of two and a half years (Black); 2 (27, 28) remained well at end of fifteen months (LaMotte); 1 (60) remained improved after observation of four months (Weeks).

Of the three operations for acute glaucoma, 1 (26) recovered; observation, fifteen months (LaMotte); 1 (43) improved; remained so after nine months (Renaud); 1 (44) preventive; no attack occurred.

Of the four operations for absolute glaucoma, 1 (8) improved as to pain; 3, no improvement and no change.

Of the two operations for hemorrhagic glaucoma, 1 (11) improved as to pain; 1 (33), improved vision during time of observation, five months.

One operation for buphthalmus had no effect.

SUMMARY.

Form of Glaucoma.	No. of Cases.	Improved.	Temporarily Improved.	Stationary.	Unimproved.
Simple chronic	38	15	5	3	15
Chronic inflammatory	16	4	3	3	6
Subacute	4	3	1	..	..
Acute	3	1	1	1	..
Absolute	4	1	..	..	3
Hemorrhagic	2	2	..	..	..
Buphthalmus	1	..	..	..	1
	68	26	10	7	25

After these 68 operations miosis is mentioned as occurring 40 times, and this condition remained for periods ranging from two days to three years. In most cases it seems to be permanent. It is mentioned that in 34 cases the tension was reduced to normal, and in 9 others it was much lower than it was before the operation. As to the effect of the operation on the lid, conjunctiva, face, etc., ptosis occurred in 36 cases and lasted

for periods ranging from thirteen days to one year. This, like miosis, is one of the most constant phenomena. Conjunctival congestion was noted in 19 cases, lasting for a variable time, usually not longer than a few days. One case persisted for three months. Increased lachrymation was observed in 18 of the cases. This was of short duration, but in one case lasted three weeks. Congestion of the face on the side operated on was observed six times, in one case lasting three months.

Neuralgia and hyperesthesia of the side of the face operated on was noted in six cases, lasting in one case for one year. Anesthesia of the face or neck on the operated side was mentioned in only two cases; in one of them it lasted three months. Hoarseness or aphonia occurred in 8 cases, lasting for a variable time, from one week to three weeks. In two of the cases dysphonia was the result of paralysis of the recurrent laryngeal, and lasted in one for nine months and in the other for two years. Dysphagia was observed in 5 cases as a result of the operation. This symptom lasted only two or three days, except in one case, in which it persisted for six months. In one case (5), for a period of several days after the operation, the patient had mild hallucinations.

The results exhibited in this series of cases, at first glance, do not seem as favorable as those presented by Rohmer,[14] who drew conclusions from a study of 74 cases collected by Bichat, to which he added 20 of his own. On these 94 cases, 114 operations were done. The following table gives a summary of the results of their analysis of these cases:

Form of Glaucoma.	No. of Cases Operated on.	Improved.	Negative.	Worse.
Simple chronic	43	36	5	2
Chronic inflammatory	34	23	10	1
Subacute	14	6	6	2
Acute	9	4	5	..
Absolute	3	1	2	..
Hemorrhagic	5	5	..	..
Hydrophthalmus	6	4	1	1
	114	79	29	6

The statistics of Ziehe and Axenfeld,[15] who studied the results in 55 cases, agree with this in the main, for many of the cases in each series are the same. Un-

14. Annales d'Oculistique, May, 1902.

15. Ziehe and Axenfeld: Sympathicus Resection beim Glaukom. Rostock, 1901.

fortunately, many of these cases, as in the present series, either do not give the final result, or were under observation such a short time as to make any statement as to the final outcome impossible. Again, in studying them, it is seen that the records of many of them are far from exact.

However, to quote Axenfeld: "There is obtained by this operation in a certain proportion of cases of simple glaucoma, a definite and important result, and, in some instances, there has been a decided improvement, even where a previous iridectomy had failed." Such cases as those reported by Grunert,[16] Demicheri,[17] Cutler, Starr[18] and Weeks,[19] in which sclerotomy and iridectomy had been unsuccessfully performed, and sympathectomy accomplished not only reduction in tension but improvement in both central and peripheral vision, speak strongly in favor of the operation in certain cases.

As was said in the beginning, I feel that positive conclusions are not yet to be reached, and will not be until more carefully selected cases can be studied for longer periods of time.

The operation in itself, while a major one, is not to be considered one of unusual danger, and with modern technic should show a very trifling mortality. The death recorded in our present series was purely accidental, and might have occurred in any other operation on the neck. With such brilliant results before us as are presented in certain cases on record, we must agree that sympathectomy is not an operation to be condemned too hastily. It certainly is not fair to condemn it when it fails to restore sight to an eye that has suffered so long from glaucoma that it is blind from atrophy of the nerve, or when it fails to check pain in an eye that is hopelessly lost from absolute glaucoma.

If it is to be compared with iridectomy at all, it should be given an early trial in any form of the disease in which it is applicable.

The statistics up to date seem to indicate that the simple chronic form is the one most suited for it, next to the hemorrhagic form, if that can be determined. As

16. Archiv. f. Augenheilk., 1900, vol. xlii.
17. Annales d'Oculistique, T cxxi, 1899.
18 Loc. cit.
19. Loc. cit.

a guide for my own practice, I should feel very much like following Abadie[20] when he says: "In acute forms of glaucoma and in subacute with intermissions, practice first iridectomy, and if it fails do sympathectomy. In simple glaucoma use miotics twice a day; if they suffice, continue them. If, in spite of their systematic employment the vision fails, do sympathectomy."

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INFLUENCE OF RESECTION OF THE CERVICAL SYMPATHETIC

IN OPTIC-NERVE ATROPHY, HYDROPHTHALMOS AND EXOPHTHALMIC GOITER.

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I. SYMPATHETICECTOMY IN OPTIC-NERVE ATROPHY.

History.—Excision of the cervical portion of the sympathetic nerve for the relief of optic-nerve atrophy was proposed and executed by the writer in 1899. (The date of the first operation was June 24.)

Report of Cases.—A report of this case was included in a paper[1] which was read before the Ninth International Ophthalmologic Congress, in 1899. From that paper I now quote:

T. J., aged 46, an inmate of the St. Louis City Hospital, a laborer, was admitted on account of blindness. There was no history of syphilis, rheumatism nor any systemic disease. The patient was of limited mentality. No history of his family could be obtained. He claimed to have had good health all his life, with the exception of an attack of malarial fever several years ago. The patient has been a moderate drinker of alcoholic beverages. In appearance he was robust, and he complained only of loss of vision, which in the left eye had been failing for eleven months, in the right for seventeen weeks according to his statement. Until seventeen weeks before this time he could see enough with the right eye to get around. Since then vision had steadily declined until he had light perception only—and this apparent only when light was concentrated on the eye by the ophthalmoscopic mirror. Vision of left eye =0.

1. Ball: On Removal of the Cervical Sympathetic in Certain Ocular Diseases—Glaucoma and Optic Nerve Atrophy. Neuvième Congrès International d'Ophtalmologie d'Utrecht, 1899, p. 551.

The pupils were widely dilated. The ophthalmoscope showed in the right eye a white disc, particularly on the temporal side; the arteries were slightly reduced in caliber, veins normal. There was shallow, atrophic cupping of the nerve head. The retina and choroid were normal, the vitreous and lens clear The left eye showed a disc of a dead white color throughout the whole area, arteries very small, atrophic excavation pronounced, veins reduced in caliber and choroid normal. The macula was not visible in this eye, owing to the much reduced blood supply. The vitreous and lens were clear. Vision was as follows: R. E. = perception of concentrated light. L. E. =0.

Diagnosis.—R. E.= optic nerve atrophy. L. E. = complete atrophy of optic nerve and retina.

Treatment.—Resection of the right superior cervical ganglion of the sympathetic was done. The operation was followed by conjunctival congestion, lachrymation and contraction of the pupil, slight ptosis and hypotonia.

No appreciable change in the patient's vision followed, and ophthalmoscopic examination made two weeks after operation showed no change in the appearance of the fundus, except that a cilioretinal artery in the upper part of the disc had doubled in caliber.

I was led to make this experimental operation for several reasons: 1. The use of glonoin is often followed by an improvement in vision in cases of simple atrophy of the optic nerve. 2. Glonoin enlarges the retinal vessels, as has been proved by ophthalmoscopic examination. 3. There is no question that in glaucoma simplex—a disease in which there is an atrophy of the optic nerve—improvement in vision follows sympatheticectomy. 4. Excision of the cervical sympathetic is followed by an increase in the blood supply of the orbital contents.

My second case of sympatheticectomy for optic nerve atrophy occurred in the summer of 1900. It has not been reported, for the reason that an assistant lost the case history. The result, however, was all that could be expected.

The patient was an Irishman, a bartender by occupation. He was about 40 years of age. For several months the vision of both eyes had steadily declined. Several oculists had given him medical treatment for simple optic-nerve atrophy without result. The poorer eye had vision equal to the counting of fingers at two feet. I excised the superior cervical ganglion of the sympathetic nerve on the corresponding side. Vision steadily increased to 20/100. The patient was lost sight of, but one year later he sent word that his vision was excellent and that he was following his vocation.

I regret that this case can not be more fully described. My third case of atrophy treated by sympatheticectomy occurred in 1901.

J. H., aged 64 years, a native of New York City, for 18 years had been a sailor. For many years he was excessively addicted to the use of alcohol and tobacco. In 1888 he contracted syphilis, for which he was treated for two months. Vision in R. E. began to fail in 1898; in L. E. in 1900. He was admitted to the St. Louis City Hospital on Jan. 29, 1901. The hospital record shows that he was in good general health. He was given large doses of mercury and iodids.

Patient came under my care on March 1, 1901. His general condition was good. Vision of R. E. =0; of L. E. = fingers at 6 inches. The ophthalmoscope showed a typical picture of simple atrophy of the optic nerves. Strychnia in increasing doses was ordered and was continued for five weeks without benefit.

On April 11, 1901, assisted by Dr. R. F. Amyx, I excised the left superior cervical ganglion of the sympathetic nerve. At this time the right eye was absolutely blind; with the left eye fingers could be counted at 6 inches. Two days after the operation he counted fingers at 15 feet. On April 27 he counted fingers at 12 feet. There was a gradual loss of vision, until at the end of a few weeks the patient was in the same condition as before operation.

Cases Reported by Other Surgeons.—Suker[2] performed a bilateral sympatheticectomy in a case of bilateral simple atrophy of the optic nerve. Before operation the visual acuity was reduced to form perception at two feet. After operation the hand could be recognized at six feet. Two years later the acuity was retained.

Renaud[3] has reported one of my cases and two of his own. In January, 1900, he made a bilateral sympatheticectomy for a unilateral optic-nerve atrophy which followed an attack of optic neuritis existing four months previously. Vision was reduced to the counting of fingers at six feet. Four and one-half months later the patient could count fingers at eighteen feet (V.= 20/100). Renaud's other case, which was one of simple atrophy, showed in two months an improvement in vision from 10/200 to 20/50. Renaud[4] has operated on another case without success.

2. Suker: New York Medical Journal, Feb. 24, 1900.
3. Renaud: St. Louis Medical Review, Feb. 1, 1902.
4. Renaud: Personal communication, April 30, 1903.

E. Gruening[5] of New York has had one case which is best described in his own words:

My experience with the excision of the superior cervical sympathetic ganglion in atrophy of the optic nerve is limited to one case. It concerned a man, 33 years of age, who had contracted syphilis fifteen years previously. When I saw him in 1902 he was entirely blind as regards his left eye, but saw well centrally with his right. Here the field was telescopic, measuring ten degrees in diameter. Vision was 20/30. He read J. 1. Pupils small. Argyll-Robertson reaction—knee reflexes lost entirely—a case of post-syphilitic tabes with atrophy of the nerves. The ganglion was removed on the right side. Vision became worse and three months later the man was totally blind.

Thus, of 8 cases in which sympatheticectomy was performed by optic-nerve atrophy, there were 4 failures and 4 improvements.

Should Bilateral Resection be Done for Unilateral Atrophy?—At the present time it is impossible to answer this question *ex cathedra*. Renaud states that "the superior cervical ganglion should be removed on both sides in all cases, whether the affection be unilateral or bilateral." It is possible that the unexcised ganglion exerts an influence on the opposite eye, the anatomic path probably being through anastomosis of fibers in the carotid plexus.

II. TREATMENT OF HYDROPHTHALMOS BY OPERATIONS ON THE SYMPATHETIC NERVE.

Few cases of congenital hydrophthalmos have been treated by operations made on the cervical sympathetic. Palmtag and Nolle removed the superior ganglion, while Schwilke and Mader performed sympatheticotomy. These four patients were 8, 2½, 4½ and 9 years of age, respectively. The tension was uninfluenced, and the vision, so far as could be determined in such young subjects, was unchanged. The operations, consequently, were valueless. Grunert[6] states that the general health of these children was not influenced by these procedures.

III. OPERATIONS ON THE SYMPATHETIC NERVE FOR THE RELIEF OF EXOPHTHALMIC GOITER.

Exophthalmic goiter is a disease belonging to the

5. Gruening: Personal communication, March 23, 1903.

6. Grunert: Die Behandlung des Glaucoms durch Sympatheticusresection, Bericht xxviii. Versammlung der Ophthalmologischen Gesellschaft (Heidelberg, 1900), Wiesbaden, 1901, p. 19.

domains of the ophthalmologist, neurologist, surgeon and general practitioner.

Without desiring to enter into a résumé of the literature of the last ten years or to excite a discussion on the nature of the disease, I will remark that there are good reasons for dividing cases of exophthalmic goiter into three groups, as advocated by Lanphear:[7]

1. Those dependent on changes in the central nervous system, in which no operative measures can be of benefit.

2. Those due to disease of the cervical sympathetic, in which excision of the ganglia may give relief.

3. Those arising from excessive thyroid secretion, in which thyroidectomy may cure.

Granting that a certain percentage of cases will recover spontaneously; that some will show great improvement without treatment; that others will recover under the rest cure, or by change of climate, or by the influence of pregnancy; and that some will recover under the use of such diverse measures as cauterization of hypertrophied inferior turbinated bodies, the removal of nasal polypi, the painting of the thyroid region with collodion, the use of the galvanic current, or of the faradic current the administration of iron, quinin, belladonna, digitalis, strophanthus, hydroiodic acid, ergot, spartein, salicylate of soda, corbolozate of ammonia, thyroid extract, etc., there will still remain a not inconsiderable number of cases in which surgical intervention will be required.

Before resorting to any form of operation it is well to remember (1) that no surgical procedure will cure all cases, and (2) that sudden death has not infrequently followed carefully planned and skilfully executed operations made on this class of patients. Harris[8] has reported the death of a lady who, having exophthalmic goiter, was operated on for the removal of a non-malignant mammary tumor and died suddenly. Lancereaux[9] has called attention to the danger of sudden death after goiter operations, and has commented on the great value of morphin in such patients. Warren[10] has ad-

7. Lanphear: St. Louis Medical and Surgical Journal, May, 1900.

8. Harris: British Medical Journal, May 4, 1901.

9. Lancereaux: La Semaine Médicale, Paris, January, 1894.

10. Warren: American Year-book of Medicine and Surgery, Philadelphia, 1896, p. 289.

vanced the idea that during the operation a toxic substance from the thyroid may gain admission to the circulation and cause death. Booth[11] states that, owing to the care which is now exercised in the removal of the diseased gland, this theory is no longer tenable.

Patients with simple goiter often do badly under general anesthetics. In addition to the dangers pertaining to such cases, the patients with exophthalmic goiter must face other dangers. The chance of death from chloroform, according to Halstead,[12] is much increased by the degenerated heart muscle and the increased irritability of the heart centers; and in the retrosternal and retroclavicular forms of goiter ether anesthesia is equally dangerous. Fütterer has shown that collapse of the trachea, which may occur after operation for any form of goiter, is due to mucoid degeneration of the cartilaginous tracheal rings. The patient makes a violent inspiratory effort, collapse of the trachea results and death occurs by asphyxia. Because of these dangers, not a few surgeons, including Kocher,[13] believe that goiter operations should be performed under local anesthesia.

CLASSIFICATION OF OPERATIONS ON THE CERVICAL PORTION OF THE SYMPATHETIC NERVE.

These procedures, which have been tried in the treatment of exophthalmic goiter, are:

1. Simple division of the cervical sympathetic (first suggested by Edmunds[14] in cases in which perforation of the cornea is threatened, and first performed by Jaboulay).

2. Ablation of the cervical sympathetic, consisting in the torsion and ablation of the nerve by means of artery forceps passed through a small incision (Jaboulay's procedure).

3. Simple stretching of the cervical sympathetic (first practiced by Jaboulay).

4. Partial resection of the cervical sympathetic (first performed by Alexander of Edinburgh, in 1889, for the

11. Booth: Radical Cure of Exophthalmic Goiter, Journal of Nervous and Mental Diseases, September, 1902, p. 521.

12. Halstead: Pathogenesis and Surgical Treatment of Exophthalmic Goiter, Medicine, September, 1902.

13. Kocher: Sixty-fourth Annual Meeting of the British Medical Association, Aug. 6, 1898.

14. Edmunds: Lancet, May 25, 1895.

cure of epilepsy, and limited by him to the removal of the superior ganglion).

5. Partial and extensive resection (excision of the upper and middle ganglia with the intervening strand).

6. Total resection of the cervical sympathetic (removal of all three ganglia and the nerve strand). This was first performed by Jonnesco.

7. Thyroidectomy with partial and extensive resection of the cervical sympathetic, was suggested by the writer in 1901, in a case under the care of Dr. F. Robert Boyd, and was practiced by Dr. J. W. Smith of St. Louis.

The comparative value and mortality of exophthalmic goiter operations can not be definitely determined, because (1) many cases ending in death have not been reported, and (2) not all of the published statistics are reliable, there being in some of the published reports an absence of differentiation between the various procedures practiced on the sympathetic nerve.

1. *Thyroidectomy.*—The general mortality of this operation is 7 per cent. (Booth[15]), while the percentage of death in cases of exophthalmic goiter is much higher. Rehn[16] of Frankfurt, who collected 177 cases, places it at 13.6 per cent. Tricomini[17] (72 cases) places the mortality at 15 per cent., and Sorgo[18] (172 cases) at 14 per cent. Jonnesco[19] claims that the mortality is over 17 per cent., and rejects the operation because of the high death rate. Kocher's[20] recent statistics are very favorable. He made 59 operations: 45 cases (76 per cent.) were cured; 8 (14 per cent.) were improved; 2 (3.3 per cent.) were slightly improved, and 4 (6.7 per cent.) died. When we remember that many of the unsuccessful cases have not been reported, it seems reasonable to place the mortality of thyroidectomy for exophthalmic goiter at 20 per cent. Rehn[21] claims 57.6 per cent. of cures for thyroidectomy. Jonnesco claims that the reported successes of this operation have been largely among those atypical cases in which the goiter long preceded the ocular and cardiac symptoms.

15. Booth: Medical Record, Aug. 13, 1898.
16. Rehn: Münchener Medizinische Wochenschrift, Oct. 10, 1899.
17. Tricomini: Il Policlinico, Roma, 1896.
18. Sorgo: Centralblatt für Grenzgeb. der Medicin, No. 1, p. 329.
19. Jonnesco: Revue Chirurgicale, November, 1897, supplement.
20. Kocher: Mittheilungen aus dem Grenzgebieten der Medicin und Chirurgie, 1902.
21. Rehn: Münchener Medizinische Wochenschrift, Oct. 10, 1899.

Doyon is a strong advocate of thyroidectomy, and would resect the sympathetic only after failure of the former operation.

The danger of sudden death after thyroidectomy is emphasized by Starr's report. Of 190 cases, not less than 23 died suddenly. Surrel,[22] who has recently discussed this subject, attributes these accidents to either an acute thyroidin intoxication, or to a sudden stoppage of the heart's action. The latter is supposed to be caused by the traction which, during the operation, is exerted on the nerves of the thyroid gland, which are intimately associated with the vagus nerve.[23] After thyroidectomy a number of complications have been observed, such as a rise of temperature, which is accompanied by a sensation of heaviness, dyspnea, tachycardia and vomiting. Hemorrhages, tetany and vocal disturbances, dysphagia and bronchopneumonia have also been observed.

2. *Ligation of the thyroid arteries,* according to Rehn,[24] gives a mortality of 28.6 per cent.; 2.4 per cent. were cured, and 50 per cent. were improved. Regarding this, Balacesu[25] says: "The method of ligaturing the thyroid arteries has been the first to be abandoned (among operations attacking the thyroid gland), because in nearly all cases the disease recurred in a few months after operation. Secondly, the execution of this operation was difficult where the thyroid was very large, especially in cases in which its relations to surrounding tissues were altered; or it predisposed to secondary hemorrhages on account of the fragility of the vessels." Kocher, Kopp and Rehn have recorded cases in which this operation was followed by tetany.

3. *Exothyropexy,* which was first done by Poncet and Jaboulay, consists in exposing the thyroid gland, and suturing it in the wound, where it is left exposed, in the hope that atrophy will occur. This operation has been abandoned by Poncet, because of the high mortality (23 per cent.) and the frequent recurrence of Basedow's disease after this procedure.

Simple Section of the Sympathetic Nerve.—Jabou-

22. Surrel: Des accidents qui peuvent compliquer l'intervention chirurgicale dans le goitre exophtalmique, Thesè de Paris, 1897.
23. De Cyon: Acad. des Sciences, 1897, Juin.
24. Rehn: Münchener Medizinische Wochenschrift, Oct. 10, 1899.
25. Balacesu: Archiv für Klinische Chirurgie, vol. lxvii, 1902.

lay[26] performed bilateral section in 6 cases and the unilateral operation in 2 cases. He records 2 cures, 5 improved cases and 1 death, which occurred 18 months after operation—a mortality of 12.5 per cent. In all of these patients the exophthalmos was influenced favorably after the first day; the thyroid enlargement disappeared slowly, while the tachycardia was scarcely influenced by the operation. He proposes that in cases in which the tachycardia is pronounced the inferior cervical ganglion shall be excised. Balacesu[27] claims that simple section influences the exophthalmos and thyroid enlargement but little, and the tachycardia not at all. Pean[28] pronounces the operation resultless and unnecessary. He advocates thyroidectomy. Gayet[29] has stated that simple section powerfully influences the triad of symptoms, and this effect is permanent. It must be remembered that Gayet's article appeared in 1896, while that of Balacesu was published in 1902.

5. *Stretching of the Cervical Sympathetic.*—In the only (Jaboulay's) case in which this operation was performed the tachycardia was markedly increased, the pulse ranging from 110 to 130 two weeks after the operation. The exophthalmos and thyroid enlargement were uninfluenced.

6. *Stretching of the pneumogastric nerve* has been tried by Jaboulay[30] in cases of exophthalmic goiter with severe cough. It is said to arrest the laryngeal spasms. This procedure must be regarded as dangerous and without curative value.

7. *Ablation of the cervical sympathetic* has been abandoned.

8. *Partial Resection* (Removal of the Superior Ganglion) *and Partial and Extensive Resection* (Removal of the Superior and Middle Ganglia with the Intervening Strand.—These procedures have gained an established position among exophthalmic goiter operations. Balacesu[31] reports 27 cases which were treated by partial resection, and were observed for periods varying from 1 to 4 years. In all of these cases there was rapid and

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26. Jaboulay: Chirurgie du Grand Sympathetique et du Corps Thyroide, p. 79, 1900.
27. Balacesu: Archiv für Klinische Chirurgie, vol. lxvii, 1902.
28. Pean: Bull. Acad. de Med., Tome iii, p. 31, 1897.
29. Gayet: Lyon Médicale, No. 30, 1896.
30. Jaboulay: Lyon Médicale, April, 1898.
31. Balacesu: Archiv für Klinische Chirurgie, vol. lxvii, 1902.

pronounced improvement. The exophthalmos disappeared within the first few days, the thyroid diminished in the first 8 days, but the tachycardia persisted, the pulse ranging from 110 to 120. The palpitation did not return, and the facial expression was much changed for the better. After a time, the tachycardia showed a tendency to decrease, but never was as pronouncedly influenced as were the other Basedow symptoms. In this series of 27 cases there were 9 cures, 11 improvements, 2 uncured cases and 5 deaths, none of which could be attributed to the operation. The mortality of these procedures is small, probably less than 5 per cent. Sudden death, however, has occurred after partial resection. One such case, which was operated bilaterally by Bernays and Simpson[32] of St. Louis, died of heart failure on the 11th day. That partial resection is not always curative is shown by a case recorded by Chauffaud and Quénu,[33] who removed the superior ganglia without influencing the exophthalmos and goiter. It seems reasonable to concede (1) that partial resection is the operation of choice in those cases of exophthalmic goiter in which the ocular and thyroid are more prominent than the cardiac symptoms; (2) that the bilateral resection should be made, but not at the same sitting, an interval of 2 or 3 weeks being advisable; (3) that the mortality is low.

9. *Total bilateral resection* is the procedure of choice among the sympathetic operations. Of 19 cases which are reported by Balacesu[34] as occurring in the practice of Jonnesco, Soulié, Faure, Peugnecz and Dépage,[35] in 14, after the second day after operation, the Basedow symptoms disappeared one after another. This improvement continued daily until cure was complete. This report is verified by the experience of Halstead[36] and Witherspoon.[37] Halstead, writing four weeks after total bilateral resection, says: "The patient's exophthalmos has greatly improved; the pulse is better, the tremor and general nervous condition are improved." Witherspoon, in 1899, was consulted by a woman aged 59 years, who

32. Bernays and Simpson: Personal communication, April 15, 1903.
33. Chauffaud et Quénu: Presse Medicale, July 3, 1897.
34. Balacesu: Archiv für Klinische Chirurgie, 1902.
35. Dépage: Societe Royale des Sciences Médicales et Naturelles Bruxelles. 1898.
36. Halstead: Personal communication, April 14, 1903.
37. Witherspoon: Personal communication, April 15, 1903.

showed moderate exophthalmos, marked enlargement of the right thyroid lobe, and a pulse rate varying from 130 to 150. She heard strange noises and had ideas of persecution; the skin was moist, and the urine showed casts and albumin. The diagnosis was chronic interstitial nephritis, associated with Graves' disease. Believing that in her general condition thyroidectomy was contraindicated, Witherspoon advised sympatheticectomy. On September 10 the operation was made on the right side. Eleven days later the left side was operated on. After the second operation the pulse showed improvement in quality and rate, the exophthalmos and enlargement of the thyroid almost completely disappeared, and her mental condition improved. In December she went on a visit to the country. In the following February, while riding, she became chilled and died two hours afterward. Up to the present time no deaths have been directly attributed to the total excision of the cervical sympathetic. The results are 63.8 per cent. of cures; 18.1 per cent. of improvements; 18.1 per cent. of failures, and no deaths.

10. *Thyroidectomy with partial resection of the cervical sympathetic* was performed on a patient of Dr. F. Robert Boyd by Dr. J. W. Smith and myself. The patient nearly died on the table from hemorrhage following the slipping of a ligature. She expired suddenly on the third day. The temperature rose suddenly and the pulse became too frequent to be counted.

The failure of thyroidectomy to relieve the exophthalmos of Basedow's disease was remarked on by Stevenson and Shears.[38] In the case of a woman, aged 25 years, from whom the right lobe of the thyroid had been removed 4 years previously, while the general symptoms were improved greatly, the exophthalmos had steadily increased. It is possible that cases presenting marked exophthalmos and thyroid enlargement without much tachycardia may be cured by thyroidectomy, combined with resection of the superior cervical ganglion.

CONCLUSIONS.

1. Excision of the superior cervical ganglion of the sympathetic nerve is worthy of a trial in those cases of simple atrophy of the optic nerve which resist measures less heroic.

38. British Medical Journal, Jan. 25, 1902.

2. It is yet impossible to say whether the bilateral operation is advisable in unilateral optic-nerve atrophy.

3. The value of sympatheticectomy in congenital hydrophthalmos has not been demonstrated.

4. In exophthalmic goiter, complete excision of the cervical sympathetic is followed by a larger percentage of cures than is any other procedure. Thus far no deaths have been recorded. The number of operations, however, is small and final conclusions can be announced only after a large number of cases shall have been treated by this method.

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PATHOLOGY OF THE CERVICAL SYMPATHETIC.

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The departure from the normal in the cervical sympathetic may be classed under two heads, namely, irritation and paralysis.

1. The symptoms of irritation are: (a) mydriasis, due to spasm of the dilator pupillæ; (b) exophthalmus, said to be due to contraction of the smooth muscular fibers of the orbit (Müller's); (c) widening of the palpebral fissure by tonic contraction of Müller's muscle; (d) contraction of the walls of the vessels of the head, face and neck, including pallor of the skin, frequently with an increase in the amount of perspiration; (e) acceleration of the heart beat.

According to Nicati,[1] paralysis of the cervical sympathetic may be divided into two stages:

First Stage.—(a) Contraction of the pupil, (b) narrowing of the palpebral fissure (ptosis), (c) decrease of the tension of the globe, (d) increased lachrymation, (e) injection of the ocular conjunctiva, and, in many cases, (f) slight exophthalmus. There is also congestion of the corresponding side of the face, anidrosis in the greater number of cases, sometimes hyperidrosis; also acceleration of the heart action in a minority of the cases.

Second Stage.—The ptosis remains. The miosis persists for some months. The miosis, consequent on removing the stellate ganglion in animals, is recovered from in two to three months.[2] The tension of the eyeball becomes normal after some weeks or months, grad-

1. Nicati, La paralysie du nerf sympathetique cervical, Lausanne, 1873.

2. Onuf and Collins, Arch. of Neur. and Psych., vol. iii, Nos. 1 and 2.

ually becoming less pronounced. What may be termed the vasomotor disturbances disappear in a relatively short time. In exceptional cases, atrophy of the tissues of the corresponding side of the face follows.

Cases of irritation of the cervical sympathetic are not common. They have been observed as being due to abscess in the neck;[3] pressure of tumors, as malignant growths, cystic goiter,[4] with exophthalmus; thoracic aneurism;[5] injuries to the neck;[6] injuries to the spinal cord, between the fifth cervical and third dorsal vertebræ.[7]

Irritation symptoms may pass over to symptoms of paralysis and again return to those of irritation, due to irregular pressure. Cystic growths are most apt to produce these phenomena. In consulting the literature on affections of the cervical sympathetic, the writer has studied the reported cases of irritation of this portion of the sympathetic nervous system for the purpose of ascertaining if any of the patients suffered from glaucoma. Quite a full list of the reported cases of this nature is given by Lloyd.[8] In none of the histories of such cases is mention made of glaucoma as a complication.

Paralysis of the cervical sympathetic may be due to the pressure of tumors, glandular swellings,[9] malignant neoplasms,[10] cicatrices in the neck, aneurism,[11] abscess,[12] wounds of the neck,[13] injuries to the brachial plexus involving the sympathetic, diseases and injuries affecting the spinal cord, spinal caries, various pulmonary affections; paralysis of the cervical sympathetic also apparently occurs idiopathically.

Tumors originating in the sympathetic and interfering with its function are extremely rare. A case of fibrosarcoma of the cervical sympathetic is reported by Abbe,[14] and he refers to cases reported by Paget, Prud-

3. Althaus, Med. Chir. Trans., vol. xli, p. 398.
4. Demere, Wurtzburger med. Zeitschr., 1862, bd. iii, S. 262.
5. Flint, "Clinical Medicine"; Walshe, "Diseases of the Heart."
6. Seeligmuller, Arch. f. Psych., bd. v., S. 835.
7. Rosenthal, "Diseases of the Nervous System," p. 216.
8. "Twentieth Century Practice of Medicine," vol. xi., p. 457.
9. Fränkel, Berl. klin. Woch., 1875, No. 3.
10. Verneuil, Gaz. des hôpitaux, April 1, 1864.
11. Gairdner, Edinburgh Med. Jour., 1855, p. 143.
12. Jewell, Chi. Jour. of Mental Dis., 1874, p. 15.
13. Weir Mitchell, "Gunshot Wounds and Other Injuries of Nerves," Phila., 1864.
14. Annals of Surgery, April, 1898.

den, Virchow, Satterthwaite and Reynolds of neurofibromata affecting the sympathetic.

Of the symptoms said to be due to abnormal conditions of the cervical sympathetic and the consequent influence on the vessels, migraine may be mentioned. This may be preceded or accompanied by disturbances of vision, (a) periodic hemianopsia, (b) scintillating scotoma, (c) monolateral transient amaurosis, and (d) monolateral photophobia. Accompanying migraine we may also have flushing of one side of the face, anidrosis or hyperidrosis, with narrowing of the palpebral fissures and moderate miosis.

The affections of the eye, supposed to be caused in greater part by abnormal conditions of the cervical sympathetic, are glaucoma and exophthalmic goiter. It is not the province of this article to enter into a discussion of the relation of the cervical sympathetic to these diseases further than to inquire into the changes, if any, that have been observed in the tissues of the cervical sympathetic occurring in individuals affected by these diseases.

THE GANGLIA OF THE CERVICAL SYMPATHETIC.

The ganglia are surrounded by a thin, firm, adherent covering of connective tissue which sends prolongations into the ganglia, dividing them into compartments of various sizes and serving as a supporting structure. A delicate capsule, composed of a single layer of cells bearing nuclei, surrounds each ganglion cell. The ganglion cells have an average diameter of .20 microns, but vary from 13 to 40 microns. The ganglion cells possess one to three processes, one of which is an axon. The cells are made up of a protoplasmic body containing a nucleus and nucleolus. Many of the cells contain a greater or less number of pigment granules. The ganglia contain numerous nerve fibers, only a few of which are medullated. The blood vessels are small and not numerous.

The nerve-trunk resembles the ganglia, except that it contains no ganglion cells, and apparently contains a greater proportion of medullated nerve-fibers.

PATHOLOGIC CHANGES.

The writer has little doubt that the ganglia of the cervical sympathetic in the aged undergo degenerative changes to some degree. It is certain that these ganglia

as examined in the dead-house vary much in size and appearance.

Hale White found in examining 33 semilunar ganglia, taken from persons dying from different causes, that most of them showed degenerative changes (Onuf and Collins).

Gustav Ricke[15] reports a case presenting symptoms of irritation of the cervical sympathetic. Autopsy showed round-cell infiltration and small hemorrhages in the superior cervical ganglion of the affected side. He thinks that paralysis of the vasomotor fibers and irritation of the oculopupillary fibers occurred.

Petrow[16] describes changes occurring in the sympathetic in constitutional syphilis. In twelve cases which he examined he found distinct alterations in the nerve elements and in the interstitial connective tissue, hyperplasia of the latter being apparent. There was pigment and colloid degeneration in the nerve-cells, alterations in the cells of the sheaths of the ganglion cells consisting of increase in size and proliferation. The endothelial cells showed secondary fatty degeneration.

Pio Foa (*Sull' anatomia del gran simpatico*) wrote concerning some changes he had observed in the sympathetic in various diseases. These were found chiefly in the cervical and abdominal ganglia, and consisted sometimes of simple or fibrous atrophy, at other times of hyperemia, sclerosis, pigmentary and fatty infiltration, amyloid degeneration, accumulation of colorless blood-corpuscles and the presence of micrococci in the blood vessels of the ganglia. These alterations are well marked in syphilis, leukemia, pellagra, tuberculosis and infectious diseases.

Mention should be made of two reports by Koster[17] on the state of the cervical sympathetic in persons who had died suddenly from sunstroke. In one case, that of a soldier, the superior ganglion of the right sympathetic was twice the size of the left and was the seat of hemorrhagic effusion; microscopically, the nerve-fibers were seen to be separated and disintegrated. There were small hemorrhages in the upper part of the right sympathetic, while slight effusions of blood were found in and around both vagi and in the sheaths of

15. Wiener med. Presse, 1884, p. 1077.
16. Virchow's Arch., 1873, bd. lvii, p. 121.
17. Berliner klin. Woch., 1875, No. 34.

both phrenic nerves. In the second case, that of a woman 21 years of age, the pathologic phenomena were a hemorrhagic infiltration and enlargement of both superior ganglia of the cervical sympathetic, while the microscope revealed the same appearances as in the other case; there were also ecchymoses as large as peas in both vagi. In the first case, the patient had lived twenty-four hours, having a pulse so rapid that its beats could scarcely be counted; there was, however, no acceleration of the respiration.

GLAUCOMA.

The ganglia excised in Ball's cases were examined by Dr. Carl Fisch[18] of St. Louis. A great number of different staining methods were employed, but those of Golgi, Marchi and Nissl were not employed, on account of the method of hardening the specimen. The changes found were approximately the same in all cases.

The most striking change was "a very marked hyperplasia of the connective tissue, which, in some places, resulted in dividing up the ganglion into small groups of nervous elements, separated by broad bands of fibrous elements." There was decided sclerosis of the walls of the vessels and the capsules of the ganglion cells were "much increased in thickness." "In Case 1, small foci of round-cell infiltration are seen in this hyperplastic growth of an inflammatory character." No "plasma or mast-cells" could be demonstrated.

The ganglion cells were "immensely" pigmented; many were in various stages of degeneration. Only a few showed normal dendritiform processes. The network of processes was reduced in volume and compressed by the connective tissue new formation. The general aspect was that of a general sclerosis, inflammatory and originating in the walls of the vascular structures. The changes in the nervous elements are attributed to pressure and inhibited nutrition.

Ziehe and Axenfeld (*Sympatheticus-Resection beim Glaucoma,* Halle, 1901) report the examination of five ganglia removed from three patients at Rostock. The ganglia were examined by Dr. Recker, Privatdocent, working in the Pathologic Institute at Rostock.

Case 1.—Capsule thick; the connective tissue that accompanied the blood vessels was also thickened. Connective tis-

18. Ninth Internat. Ophthal. Congress. Utrecht, 1899, p. 554.

sue poor in nuclei. Often the adventitia was thicker than the remaining portion of the wall of the vessel, plus the lumen of the vessel. A slight increase in the small cells was observed in the vicinity of the vessels. No change in nerve elements. Both ganglia presented the same microscopic appearance.

Case 2.—Right ganglion; marked diffuse interstitial sclerosis, most pronounced in the vicinity of the larger blood vessels. Nerve elements normal. The left ganglion showed the same changes, but to a less degree. Leucocytes slightly increased in number.

Case 3.—The left ganglion, which was the only one removed, showed increase of the connective tissue about the blood vessels; adventitia very much thickened. Diffuse interstitial sclerosis absent.

Lodato[19] examined two ganglia removed from a patient with glaucoma and found hyperplasia and sclerosis of the connective tissue and a peripheral small-cell infiltration. The sclerosis was more marked in the ganglion from the older patient, the small-cell infiltration in the ganglion from the younger patient.

In the first he found a number of small hemorrhages which had destroyed some of the nervous elements. There was some degeneration of a few of the medullated nerve-fibers. No change in the nerve-elements in the second case.

Lodato questions whether the small-cell infiltration might not have produced an irritation which could have caused a hypersecretion of fluids into the globe, and thus have established the first stage of the glaucoma. There is no report of control examinations.

Albertotti[20] gives an example of ten superior cervical sympathetic ganglia, the cut being reproduced from a photograph, which shows them to be of various sizes and shapes.

Cutler[21] reports, regarding the microscopic examination of one superior cervical ganglion removed from a patient suffering from glaucoma simplex, as follows:

Specimen 5 centimeters long, ½ centimeter in diameter. At one point for 1½ centimeters is a thickening. Sections through whole length of specimen show large ganglion cells. In these cells the chromophilic bodies do not show the normal size and arrangement, and many cells show small granules of pigment. A growth of connective tissue is between the ganglion cells. Nerve fibers are normal.

19. Arch. di ottalm., vol. viii, p. 358.
20. Ann. di ottalm., Naples, xxix, p. 472.
21. Annals of Surgery, Phila., September, 1902.

When we take into consideration the fact that degenerative changes in the cervical sympathetic occur in the old, whether there is marked evidence of disease or not, it becomes apparent that it is necessary to make control examinations before we can reach any reliable definite conclusion regarding the condition of the cervical sympathetic in individuals suffering from glaucoma, or, in fact, in any disease supposed to be due to pathologic changes in the cervical sympathetic. Such control experiments were made by Dr. Ira Van Giesen, in connection with the examination of the ganglia removed, in the cases reported by the writer.[22] His report follows:

Seven ganglia have been examined microscopically, including two bilateral operations, comprising thus five different cases. The work has been paralleled by the examination of control ganglia taken from subjects as near as possible the same age as the operation cases. As the control studies are very important in an examination of this kind, the normal ganglia were subjected to precisely the same steps as in the operation cases, and carried along with them side by side. Four ganglia of normal subjects were studied as controls and secured in autopsies averaging about twenty-four hours after death. (Thus far, however, but two of the control ganglia have been complete for study.)

We have endeavored to bring to bear on the question as comprehensive an examination as possible, and the technic has been directed toward all of the structures of the ganglion in the following order: (1) The detection of any cytologic changes in the neuron cell bodies. (2) A special study of the so-called pigment granules in the neuron cell bodies. (3) An examination of the connective tissue framework of the ganglion. (4) A study of the blood vessels; and (5) the examination of the medullated and non-medullated fibers.

Special methods, both of fixation and staining, have been used for each of these points in both sets of ganglia—the operation cases and the control cases—and in all some three hundred sections have been examined. Ten different fixations have been employed, as well as the several varieties of staining methods best adapted for the demonstration of each of the objects of examination.

1. *The Neuron Cell Bodies.*—Throughout the series of operated cases, the neuron cell bodies show the normal arrangement and distribution of the chromophilic granules. There are no evidences of degeneration, nor is there any atrophy or signs of disappearance of the neuron cell bodies. In a very

22. Trans. Amer. Ophth. Soc., 1902, p. 455.

few places, in fact, of quite exceptional occurrence, there are appearances which might be considered as similar to the form of chromatolysis in the centers of the neuron cell bodies seen in the central nervous system. This, however, is also seen in the control cases, and it seems to be of no significance in relation to the production of the glaucoma.

2. *The Pigment Granules.*—The capsules of the ganglion cells are also without alteration. The pigment grains are certainly increased in the glaucoma cases as compared with the control cases. A larger number of cells contain pigment grains in the glaucoma cases, and the aggregate volume of the pigment grains is greater. While the control cases contain a considerable amount of pigment particles, this can be reckoned as being only fifty to sixty per cent. of the quantity in the operation cases.

3. *The Connective Tissue.*—Studied in specimens prepared in Fleming's weak and strong solutions and stained by the picric acid fuschin method, the connective tissue framework shows no signs of proliferation or degeneration in the glaucoma cases. One would not be able to distinguish between the operation cases and the controls, judging by the connective tissue.

4. *The Blood Vessels.*—These were examined with especial attention, both in the substance of the ganglion and in the loose connective tissue surrounding it. The vessels are normal.

5. *The Fibers.*—The medullated fibers in the ganglion are so relatively few as compared with the non-medullated fibers that Weigert's method of staining the medullated sheath leaves the section quite decolorized. There are not enough medullated fibers to take the stain. Under the microscope, however the bundles of fibers in the ganglion show here and there the darkly-stained medullated fibers among the axons. Compared with the controls there seems to be no differences in the non-medullated fibers.

Summary.—We find, then, that as far as our methods of examination of hardened material go the ganglia seem to be normal with the exception of an excess of pigment in the neuron cell bodies. and as to the significance of this, if it has any, we are entirely as yet in the dark. The result of the examination does not positively preclude the existence of a lesion in the ganglia. (The ganglia were examined at the new pathologic laboratory of the Women's Infirmary of New York.)

Dr. W. H. Wilder of Chicago has kindly permitted me to refer to the microscopic findings in the ganglia removed from patients with glaucoma in his service. The examinations were made by Dr. Sidney Kuh, who reports as follows: Excess of pigment in the ganglion

cells (age a factor?); cells not round, often appear shrunken; eccentric nuclei, occasionally only the nucleolus visible; cells at times vacuolated; mast cells; vascularity. All of these findings were present in each case except the second finding (that of the cells not being round), as in some of the specimens the cells were perfectly round.

Onuf and Collins[23] write:

Concerning the morbid findings in cases of Graves' disease, Moebius has recently written: "All sorts of conditions have been described; the ganglia are too large or too small; the nerve too thick or too thin; there is too much connective tissue or too few nerve cells; the nerve cells are deformed, shrunken, or pigmented; there are small hemorrhages, destruction of nerve fibers, etc., etc. To all of which we make an affirmative, choosing to disregard the writer's attempt at irony. We have learned in recent years that in individuals dying of long-standing nervous disease, the so-called functional as well as organic, there are also invariably, especially if the individual be somewhat advanced in years, retrogressive changes in the nervous system. Although Moebius comes to the conclusion that in the majority of cases of Graves' disease nothing characteristic or essential is to be found in the cervical sympathetic to explain the pathogenesis of the disease, it does not seem to us that investigation of the vegetative system of nerves in its peripheral and central distribution has been sufficiently comprehensive to give tenability to his position."

The following report is from the examination of nine ganglia removed from patients suffering from exophthalmic goiter. Five of these patients were in the practice of Dr. B. Farquhar Curtis, who has kindly permitted me to make use of the report. The examinations were made by Dr. F. C. Wood, pathologist to St. Luke's Hospital, to whom I am indebted. I wish to express my thanks to both these gentlemen for their courtesy. This report is of practical value because of the control examinations, which were made in connection with the examination of the ganglia removed from patients suffering from exophthalmic goiter.

1. There is no definite increase in the connective tissue of the ganglia.

2. Pigmentation of the ganglion cells is quite constant and abundant, though not present in all cells.

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23. B. Onuf and Joseph Collins: "Experimental Researches on the Cervical Sympathetic," etc., Archives of Neurology and Psychopathology, vol. iii, Nos. 1 and 2, p. 217.

3. A small proportion, always less than half, of the ganglion cells shows a central chromatolysis when stained by Nissl's method. In some cells the change was advanced and no chomophilic bodies could be seen; in others they were clustered about the periphery of the cell. The nuclei were often eccentric in the degenerated cells.

4. No fiber degeneration could be demonstrated. All the ganglia showed about the same changes.

Control ganglia from autopsy cases dying from a variety of diseases did not show marked chromatolysis, though an occasional cell with degeneration could be seen. The amount of pigment formed was variable in these controls. It was more abundant in the aged than in adults, but a certain amount seems to be present in some of the ganglion cells of the sympathetic, at least in cases which I have been able to examine.

Reports of changes in the cervical sympathetic observed in different pathologic conditions affecting the system locally and generally, make it evident that as yet no change has been found that is peculiar to glaucoma. The findings in the cases of Ball, Ziehe and Axenfeld, Lodato and Cutler, are uniform in regard to the hyperplasia of connective tissue. This was also found by Petrow in cases of constitutional syphilis, and by Pio Foa in patients with various diseases. Slight infiltration of small cells does not appear to be peculiar to glaucoma.

Changes in the nervous elements are reported by Ball, by Cutler and by Kuh. These were not observed by Ziehe and Axenfeld, nor by Lodato, except in the presence of pigment granules. Changes in the ganglion cells were observed by Petrow in individuals suffering from constitutional syphilis. The validity of the statements regarding the uniform increase of connective tissue is somewhat shaken by the results of Van Giesen's examinations, as no such increase could be demonstrated in the seven ganglia which he examined. Kuh also fails to mention an increase of connective tissue.

The testimony in our possession is not sufficiently conclusive to enable us to say that there is any constant change in the cervical sympathetic peculiar to glaucoma. Nor is it sufficiently conclusive to exclude the possibility of such constant change. Farther and more careful research is necessary; first, probably along the lines suggested by Dr. Van Giesen, viz., by means of the Ehrlich methylene blue method with fresh ganglia or by

other equally delicate methods for the purpose of determining the conditions of the processes of the neurons and the cell structure, and, second, a study of the pigmentation of the neurons, which must be made in comparison with control studies.

DISCUSSION

ON THE PAPERS OF DRS. DE SCHWEINITZ, WILDER, BALL AND WEEKS.

Dr. Melville Black, Denver—It has been a great privilege to listen to these papers, and I am sure we must all feel that we know more about the subject now than we did before. It is a particularly interesting subject to me, and I believe that we can feel from the statistics presented so far that the operation is one of value. It is an operation, however, that is to be properly considered. My own personal feelings are that it should not be performed as a last resort, but really as a first one. The statistics of the operation will be vitiated, and have been up to the present time, by attempting it as a procedure where nothing could possibly be of any benefit. If sympathectomy is to be of any service it must be before the filtration angle is blocked or closed. If this angle has been occluded it is a question if the operation can be of any permanent benefit. It would seem to me that where eserin has a prompt action in relieving tension and pain and in improving vision and bringing up the field, that the action of sympathectomy should be correspondingly good and more permanent; that is, we can liken somewhat the after-effects of sympathectomy to the effects we obtain from the use of eserin. Of course, we can not continue the use of eserin indefinitely, and if we have in this procedure something permanent, it is certainly of great value.

I am inclined to believe that the results will not be as permanent as we would wish. With watching this one case of mine it has seemed to me that the eye is getting from some source more and more sympathetic nerve power. The ptosis is subsiding; the eye is no longer congested; the pupil is becoming more nearly the size of its fellow; at one time we had .50 diopter of myopia—we now have .50 diopter of hypermetropia. Therefore it would seem to me that this eye is gradually regaining its sympathetic nerve supply.

It would seem to me that where this operation is done a sufficiently extensive procedure should be adopted to insure as much cutting off as possible of the sympathetic nerve supply; and that therefore it would seem well to excise the middle ganglion with the superior. Any one who has watched the operation will have noticed how associated these two ganglia are and how easy it would be in removing the superior alone to have a supply from the middle. Dr. Free-

man, Denver, has operated on ten cases, removing both ganglia. Only one of these operations, however, was done for glaucoma. He has seen in his practice no undesirable results following this procedure, and his opinion was, as I obtained it, that the operation was a comparatively easy one unless the subject were an enormous, bull-necked individual. The scar resulting is slight, provided a buried suture is placed, and in the course of three or four months it is scarcely possible to find a scar. The only thing of serious consequence that may follow is neuralgia, and that seems to be due to rather unnecessary bruising of some of the nerves that come off through the vertebræ.

I think that this operation is one that we should all consider, so far as our statistical results present, as being one of value, and while we should not embrace it with too much enthusiasm, yet at the same time we should give it the benefit of the doubt as being of some service, and we should not depend on the operation only where iridectomy has failed and all other known procedures have failed. It should be tried first, not last. Several cases have been reported where the operation has been of value even after iridectomy has failed. This might lead us to think that in certain cases ganglion excitation existed and that the removal of the ganglia relieved that irritation, which might have been the beginning cause of the glaucoma.

Dr. G. C. Savage, Nashville, Tenn.—I believe we have some reasons for holding the opinion that the sympathetic nervous system is the source of power that Nature has given us for the correction of astigmatism. That in early life every astigmatic eye has the power of correcting a considerable portion of its defect, if not all, is now universally believed. One must certainly be convinced that Nature has furnished some power by which this defect is remedied. It is not in Mueller's muscle, nor in the third nerve. In my own case atropin and homatropin were used to uncover my error of refraction, but both failed. I am to-day wearing a lens four times as strong as that with which I commenced. Each time the increase was made I got additional relief, until finally the full strength lens was given. I happened to be in Dr. Burnett's office in 1889 and my corneal astigmatism was the same then as it is to-day. A considerable portion of my astigmatism was corrected by some means within the eye in spite of a mydriatic.

Only two meridians of any cornea that is astigmatic have a focus—the two principal meridians. One is the meridian of greatest curvature, and the other of least curvature. When Mueller's muscle, supplied by the third nerve, contracts, the lens is made more convex, and the two foci are brought into definite relation with the retina, but not closer to each other. hence they are not made to fuse. The other muscle in the ciliary body is that of Bowman, which I believe is controlled

by the superior cervical sympathetic. If under the influence of the sympathetic some fibers of Bowman's muscle can be thrown into contraction while others are not, it would result in tilting of the lens. When the lens is tilted on an axis in the plane of the meridian of greatest curvature the two foci are made to approach each other, and if the tilting be far enough they are fused into one. The power given us by Nature for the correction of astigmatism is in Bowman's muscle, and I believe it acts under the influence of the superior cervical sympathetic ganglion.

Dr. George F. Suker, Chicago—I maintain that the relation between any form of glaucoma and the sympathetic nervous system, including the cervical, is still open for considerable debate. We do not to a certainty know the physiologic tracts of the cranial sympathetic fibers in all instances; nor do we know whether or not these sympathetic fibers decussate in all individuals as do the cranial nerves proper. The ganglion of Ribes, situated on the anterior communicating artery, is not present in every instance according to some anatomists. Yet, if it is present, it is here where the cephalic extremities of the ascending branches of the cervical sympathetic fibers join and cross. This point may explain why, in some cases, a unilateral excision of the ganglion is of only temporary benefit. For, if this communication does exist, it is not unreasonable to suppose that the opposite side is furnishing the abnormal stimulus through the intact cephalic ends of the excised side. Just as the other corresponding nerve centers take up the function of its fellow when it is destroyed, so may the sympathetic system, by means of its ganglia, do the same. This fact may and does explain why in Dr. Black's case there was a return of the function of the sympathetic with its detrimental effects on the side operated on.

There is no justification in excising the middle cervical ganglion as well as the superior for glaucoma. However, it is very necessary to cut the connecting cord and excise that ascending branch of the middle ganglion which connects with the ascending fibers of the superior ganglion high up in the neck. It is only the cavernous and carotid plexuses of the superior ganglion which have any relation to the eye. For reasons already stated it is necessary to completely destroy the connections between these two ganglia.

The ciliary or lenticular ganglion must also be considered if we expect to explain the relation of the sympathetic fibers to glaucoma. For, it is the upper two-thirds which contain sympathetic filaments supplying the anterior segment of the eye. The lower third of this ganglion receives a branch of the third nerve. Furthermore, the sympathetic fibers in the rami communicantes, which are closely associated with the fifth nerve and enter the eye along with the optic nerve, must be

seriously considered. These branches also supply the segment of the eye around which centers the pathology of glaucoma. The experiments of Anderson,[1] Delens[2] and Rohmer[3] with the sympathetic supply of the eye are to be considered in solving its relation to glaucoma. Especially are these various sympathetic fibers and ganglia to be surgically thought of in glaucoma, for we know that the superior cervical is frequently, if not invariably, histologically changed. What is true for this ganglion may hold true for the others also.

In no case of glaucoma have all the sympathetic fibers and ganglia, on one or both sides, supplying that eye ever been severed. Experimentally they have, then tension was reduced and the iris remained contracted, both permanently.

It is questionable, as Dr. de Schweinitz has stated, whether any trophic actions can be ascribed to the sympathetic nerves. As yet we are not in a position to attribute any trophic functions to certain kind of nerves. The untoward effects which follow the extirpation of the superior sympathetic ganglion are trivial and not permanent. The only one to receive any consideration is the enophthalmus; this, however, is only slight and does not supervene in every case.

The statistics here given by Drs. Wilder and Ball show that the operation was undertaken in such cases as might well be called desperate. Therefore, the operation has not been awarded a fair trial. There is no doubt that in well-selected cases it will accomplish what an iridectomy will not. In my hands the operation has been successful in a few instances, as the reports of the cases show. What good the excision of the ganglion will do in optic atrophy is yet debatable. In the case on which I operated I did obtain a decided benefit, though temporary. Dana of New York tried it in a case of tabetic atrophy, though with what success I could not ascertain.

Several years ago I was quite enthusiastic concerning the future of sympathectomy; but of late I have become very conservative, as my paper before this Section in 1901 clearly demonstrated.

Dr. Edward Jackson, Denver—The trend of the papers would seem to indicate that we are not in a position to decide many questions in reference to the use of excision of the sympathetic ganglia in glaucoma. Yet in going over the literature one point seemed pretty clear to me, and that is confirmed this morning. Dr. Black broached it when he said that the case in which excision does good is the case favorably influenced by eserin. I think there is enough evidence now, although it lies in a very small minority of the published

1. Jour. Phys., vol. xxviii, No. 3.
2. Bull. de la Soc. de Chirurgie, April, 1902.
3. Annals d'Oculistique, July, 1902.

cases, to indicate that sympathectomy, or excision of the ganglia, will do good in the cases that would be benefited by iridectomy. If we consider apart those cases in which iridectomy would have been a hopeful operation, I think the record for sympathetic excision is very promising. That might appear to be saying that operations on the sympathetic had no place where iridectomy is an established operation, but such is not the case. I think sympathectomy may be of value in an important class of cases; as where one eye has been lost and it is difficult to get the patient to consent to an operation on the other eye at the stage where the operation is most hopeful, where iridectomy can not be done, or the patient can not be induced to have it done, and yet where if it were done the probabilities would be in favor of it, we are now justified in urging operation on the sympathetic. The cases where iridectomy is reported to have been done and no good accomplished, and then sympathectomy has been efficient, might seem to lead in another direction. I have seen one case where iridectomy did no good and sympathectomy afterwards restored vision. But it may be that in some of these cases where iridectomy is said to have been done it has not been a broad, complete excision of the iris, which I believe necessary to give iridectomy its best effect.

Dr. G. E. de Schweinitz, Philadelphia—The members of the Section must have realized that it has been impossible in presenting a résumé of the physiologic side of this question to read in detail the experiments and observations on which the conclusions were based. For example, I did not have time to discuss the question of the pupil-dilating fibers which do not run in the sympathetic system, although in the extended paper I have made reference to them. I confess that I am distinctly skeptical as to the permanent value of sympathectomy in the treatment of glaucoma, although I realize that a certain number of brilliant results have followed this operation, and also realize that at present our statistical information is to a certain extent misleading, because the operation has in most instances been utilized as a last resource, and therefore the results of prompt interference according to this method are not at our disposal, or, at least, at our disposal in a most limited degree. Dr. Black's idea that if the effect of eserin on a glaucomatous eye is good, we may reason that sympathectomy would likewise be followed by good results, does not seem to me to be an entirely safe guiding principle. Eserin accomplishes its good in those cases in which it is able to release the filtration angle from blockade by contracting the pupil and drawing the periphery of the iris away from the danger of adhesive inflammation to the structures in the filtration angle. Now, in a certain number of cases, perhaps in the majority of cases in which sympathectomy has been performed, the process

has been a chronic one in which pronounced blockade in the filtration angle was lacking, cases in which it is possible that there may have been a hypersecretion of the intra-ocular fluids, or an increased serosity. Cases of acute glaucoma are just the ones in which strong solutions of the myotics give frequently the best temporary relief, and they are certainly not the ones in which the sympathectomy is advisable, at least, as far as our present knowledge goes. I entirely agree with Dr. Suker, and all physiologic investigation is on his side, that it is not necessary to excise the middle ganglion. Excision of the superior ganglion, which is the relay station for the sympathetic nerve supply for the whole of the head, accomplishes everything that can be accomplished by this operation in so far as the relief of glaucoma is concerned. Referring to Dr. Savage's interesting observations on his own eyes, I may say that in the extended paper I have reviewed at some length the action of the sympathetic on the eye in its relation to accommodation and refraction. The evidence is exceedingly contradictory, and the whole subject is an inviting one for further research.

Dr. Wm. H. Wilder, Chicago—The report of the histologic appearance of the ganglia that were excised was not read, but if any of you are interested in seeing the specimens they are on exhibition in the next room. The ganglia do not show, as was stated by Dr. Weeks, any increase in connective tissue, but one can see in the specimens that there is an increase in the adventitia of the coats of the vessels and that there is considerable pigment in the cells.

One important question comes up in connection with the statement made by Dr. Black, that he considers that where there is good contraction of the pupil with eserin sympathectomy would be indicated; one case I have reported, Case 7, makes me doubt seriously whether we should resort to sympathectomy or to iridectomy first in these cases of simple glaucoma. I am skeptical about the value of iridectomy in true simple glaucoma, particularly where the anterior chamber is of normal depth, and it is in such cases that sympathectomy should do good. We can not place much reliance on either procedure, but perhaps we can rely as much on sympathectomy as on iridectomy. The unpleasant experience in Case 7 suggests that possibly it might be safer to do the iridectomy first. In spite of the sympathectomy in this case, the tension and the central vision remained the same; the peripheral vision continued to contract until it was as though the patient were looking through a narrow gun barrel. I did an iridectomy and there was hemorrhage from the choroid and the eye was lost. A similar case has been reported by Mohr. However, in such a case the same accident might happen if sympathectomy had not been done.

It is not fair to condemn the operation when it fails to restore an eye that has atrophy of the optic nerve, or when it fails to relieve pain in an eye lost from glaucoma. It should be given an early trial. The statistics indicate that the simple chronic form is the most suited for the operation, with the hemorrhagic form next.

Dr. J. M. Ball, St. Louis—As to the pathologic changes found in the ganglia, we have found in exophthalmic goiter that the same pathologic condition exists. It is the same in each of these conditions—an overgrowth of connective tissue, a separation of the nerve elements and the presence of pigment. I have been told by Dr. Fish of St. Louis that the same changes are found in multiple sclerosis and in tabes.

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